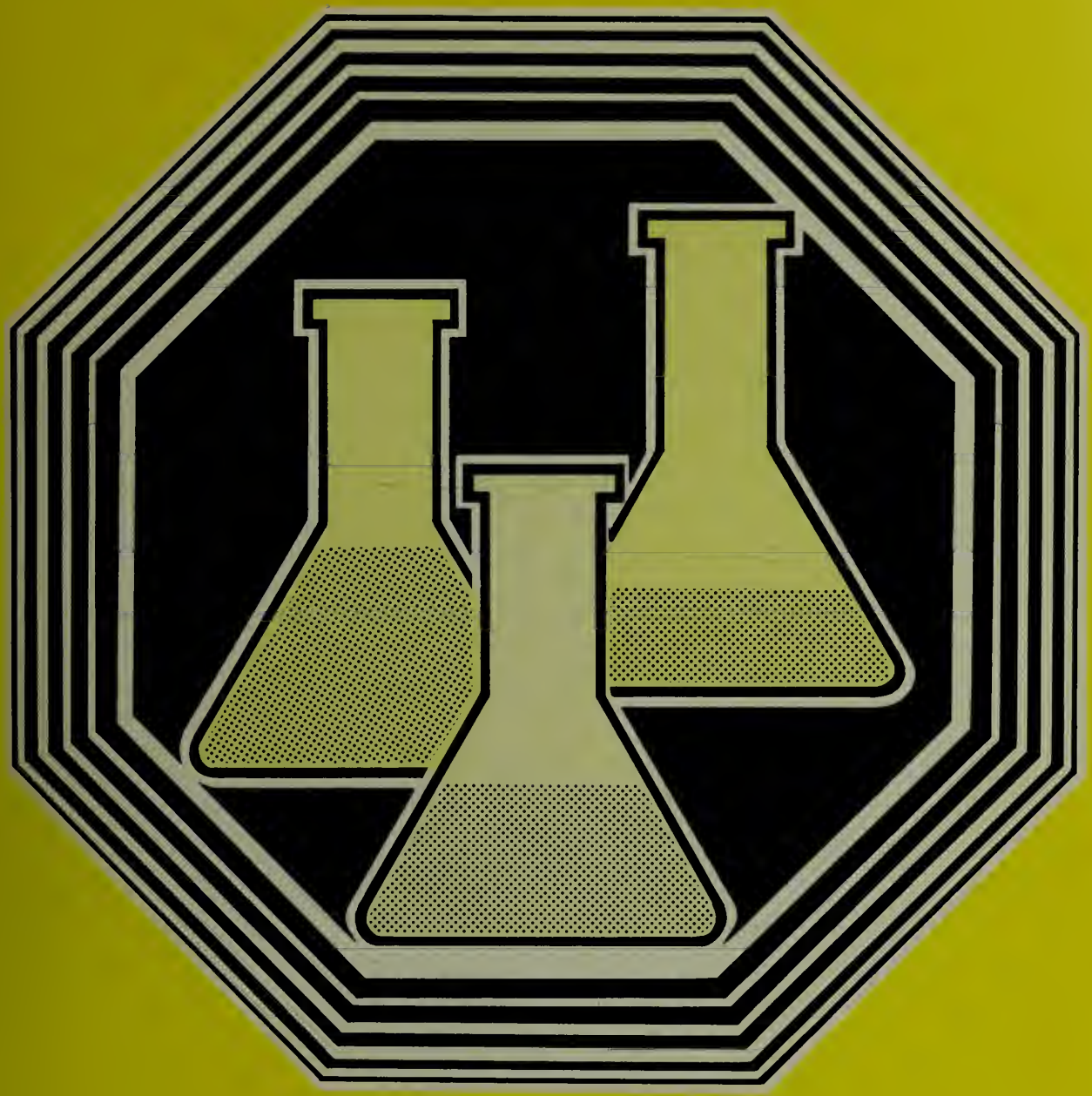

POTENTIALLY HAZARDOUS CHEMICALS

INFORMATION GUIDE

Alberta
EDUCATION
JUNE 1981

FOREWORD

The *Potentially Hazardous Chemicals Information Guide* has been developed to promote safety in Alberta schools by providing teachers and school administrators with information on the hazards of a number of chemicals commonly found or used in schools. The guide follows recent efforts by Alberta Education, in cooperation with Alberta Environment, the University of Alberta, and the R.C.M.P. to collect and dispose of hazardous chemicals present in the province's schools. Through increased awareness of the potential hazards associated with the storage and handling of certain chemicals it is hoped that Alberta schools will continue to be safe working and learning environments.

The information contained in this guide has been compiled from sources believed to be reliable, accurate and representative of the best opinions on the subject as of 1981. While every reasonable effort has been made to provide dependable information, the authors and Alberta Education cannot assume responsibility for the validity or completeness of all chemical references given or for the consequences of their use.

The guide provides information on the hazard ratings associated with particular chemicals, and suggests procedures for their proper handling, storage and disposal. The information given should be viewed as general guidelines only. Procedures noted may vary depending on the stability of the chemical in question, facilities available to the school for disposal, and other circumstances peculiar to the situation. It is recommended that other sources of expertise be consulted wherever and whenever circumstances or chemicals of an unusual or questionable nature arise.

A major feature of the guide is the identification, within present Alberta science programs (junior and senior high levels only) and prescribed science learning resources, of instructional activities that involve the use of chemicals noted in the guide. For those activities involving chemicals of a higher order of safety hazard, an attempt is made to suggest alternative instructional activities that illustrate the concept or phenomena being studied. In some instances it is recommended that the instructional activity be omitted completely.

The new 1981 elementary science program does not require the use of potentially hazardous chemicals noted in this guide. The elementary science curriculum guide should be consulted for further information regarding the use and handling of chemicals required in the 1981 elementary science program.

It is recommended that teachers consult this guide whenever chemicals noted are stored and used for instructional purposes in the school.

G. S. Popowich
Associate Director of Curriculum

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Editor: Mrs. L. McCardle
Cover Design: Shih-Chien Chen

PROFESSIONAL AND TECHNICAL REFERENCES

Much of the data in this guide has been taken from a manual on the Safety and Disposal of Hazardous Chemicals prepared by the authors for the Department of Chemistry, University of Alberta.

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COPYPRIGHT

LEGEND OF HAZARD RATINGS

T Toxic
E Explosive
R Reactive
C Carcinogenic

Health

4 Can cause death or major injury despite medical treatment.
3 Can cause serious injury despite medical treatment.
2 Can cause injury. Requires prompt treatment.
1 Can cause irritation if not treated.
0 No hazard.

Fire

4 Very flammable gases or very volatile flammable liquids.
3 Can be ignited at all normal temperatures.
2 Ignites if moderately heated.
1 Ignites after considerable preheating.
0 Will not burn.

Reactivity (Stability)

4 Readily detonates or explodes.
3 Can detonate or explode but requires strong initiating force or heating under confinement.
2 Normally unstable but will not detonate.
1 Normally stable. Unstable at high temperature and pressure. Reacts with water.
0 Normally stable. Not reactive with water.

NAME OF COMPOUND	HAZARD	HEALTH	FIRE	REACTIVITY	COMMENTS
Acetic anhydride	T	2	2	1	Flammable; causes burns.
Acrolein	R	3	3	2	Extremely flammable; gives off poisonous vapor; irritating to skin, eyes and respiratory system; may polymerize violently.
Acrylic acid	T	3	2	2	Flammable; causes burns; irritating to skin, eyes and respiratory system.
Aluminum chloride	R	3	0	2	Causes burns; irritating to skin, eyes and respiratory system; reacts vigorously with water.
Ammonium hydroxide (concentrated)	T	NH_3 gas 2	1	0	Causes burns; irritating to skin, eyes and respiratory system. Store in a cool place away from concentrated acids. Use in fume hood.
Ammonium oxalate	T	–	–	–	Harmful if taken internally.
Aniline	T	3	2	0	Toxic in contact with skin; gives off poisonous vapor.
Antimony and compounds	T	Sb 3 $SbCl_5$ 3 SbF_5 3	2 0	– 1 1	Poison; irritating to skin, eyes and respiratory system.
Antimony trichloride	R				Skin irritant.
Arsenic and compounds	T	As 3 As_2S_3 3 As_2S_3 3	2 1 1	– 0 0	Serious risk of poisoning by inhalation or swallowing; danger of cumulative effects; irritating to skin, eyes and respiratory system.
Arsenic trichloride	T	3	–	–	Serious risk of poisoning by inhalation or swallowing; danger of cumulative effects; irritating to skin, eyes and respiratory system.
Azides	E	3	2	2	Toxic if taken internally; contact with acids liberates a toxic gas; irritating to skin and eyes; may explode with impact, friction or heat. See data sheets for sodium azide and phenyl azide.

Barium compounds (except barium sulfate)	T	$Ba(OH)_2$ 2 $Ba(NO_3)_2$ 1 $BaCl_2$ 2	– 0 0	– 0 –	Poison, harmful if taken internally. See data sheets for barium chloride, barium compounds, barium hydroxide, barium nitrate and barium sulfate.
Benzal chloride	R	–	–	–	Vapor irritating to eyes; poison: reacts vigorously with water.
Benzene-sulfonic acid	T	–	–	–	Causes burns; irritating to skin and eyes.
Bromine	T	4	0	0	Gives off very poisonous vapor; causes severe burns. Store bromine solutions in cool area away from sunlight and separate from combustible or organic material.
Cadmium and compounds	T	Cd 3 $CdCl_2$ 3 CdO 3	2 – –	0 – –	Harmful by inhalation; harmful if taken internally.
Calcium carbide	R	1	4	2	Contact with moisture liberates the explosive gas, acetylene.
Carbon disulfide	T, E	2	3	0	Extremely flammable; gives off very poisonous vapor
Carbon tetrachloride	C, T	3	0	0	Gives off poisonous vapor.
Chlorates	R	K 1 Na 1 Ca 2	0 0 0	2 2 2	Explosive when mixed with combustible material; harmful if taken internally. See data sheets for potassium chlorate and sodium chlorate
Chlorine	T	3	0	0	Toxic by inhalation; irritating to skin, eyes and respiratory system.
Chloroform	C, T	2	0	0	Harmful vapor.
Cyanides (water soluble)	T, R	Na 3 Ca 3 K 3	0 0 0	0 0 0	Serious risk of poisoning by inhalation, swallowing or skin contact; contact with acids liberates a toxic gas.
Dimethyl phthalate	T	2	1	0	Irritating to mucous membranes and eyes; depressant if swallowed.
Dioxane	T(R)	2	3	1	Highly flammable; may form explosive peroxides; harmful vapor.

Ethers (except petroleum ether)	E	dimethyl 2 diethyl 2	4 4	1 1	Flammable, may form explosive peroxides on exposure to light and air; harmful vapor. See data sheet for diethyl ether and di-n-butyl ether.
Fluorides (water soluble)	T	Na 2 NH_4 3 K 3	0 0 0	0 0 0	Toxic if taken internally; dust is harmful to eyes, lungs and skin. See data sheets for potassium fluoride and sodium fluoride.
Formaldehyde solution	T	gas 2 soln 2	4 2	0 0	Flammable; serious risk of poisoning by inhalation or swallowing; causes burns; irritating to skin, eyes and respiratory system. Store in cabinet separate from oxidizing agents or alkalies.
Hydrazine (solution and salts)	E	3	3	2	Causes burns; irritating to skin and eyes. See data sheets for hydrazine, methylhydrazine and dimethylhydrazine.
Hydrides (inorganic)	R	Na 3 Li 3 $NaAlH_4$ 3	3 4 1	2 2 2	Flammable in moist air; violent reaction with water; avoid breathing dust. See data sheets on aluminum hydride, lithium aluminum hydride, potassium hydride and sodium hydride.
Hydrochloric acid (concentrated)	T	3	0	0	Irritant vapor harmful to eyes, lungs and skin; causes burns. Store with mineral acids in cool, well ventilated cupboard separate from oxidizing materials and bases. Use in fume hood.
Hydrocyanic acid (Prussic acid)	T	4	4	2	Extremely poisonous gas and liquid; poisonous by skin absorption; highly flammable.
Hydrofluoric acid	T	4	0	0	Gives off very poisonous vapor; causes severe burns which may not be immediately visible or painful; even very slight contact is dangerous.
Hydrogen peroxide (> 30%)	R	35-52% 2 >52% 2	0 0	1 3	Strong oxidant; causes burns; contact with combustible material may cause fire. Store dilute solutions in cool, dark place.

Hydrogen sulfide	T	3	4	0	Extremely hazardous; very toxic by inhalation; high concentrations cause immediate unconsciousness; insidious poison which fatigues sense of smell at low concentration; extremely flammable.
Iodine	T	–	–	–	Vapor harmful to respiratory system and eyes; causes burns. Store in dark away from ammonia.
Lead compounds (except lead or lead nitrate)	T	Acetate 3	–	–	Harmful if taken internally; danger of cumulative effects; avoid breathing dust. See data sheets for lead acetate, lead choride, lead nitrate, lead salts and lead sulfate.
Maleic anhydride	T	3	1	1	Irritating to skin,eyes and respiratory system.
Mercury	T	3	–	–	Poisonous vapor and liquid; danger of cumulative effects through continuous exposure to low concentrations of vapor or frequent skin contact.
Mercury compounds	T	3	0	0	Poisonous dust; serious risk of poisoning by inhalation, swallowing or skin contact; danger of cumulative effects; causes irritation of skin and eyes.
Methanol	T	1	3	0	Highly flammable, vapor and liquid are harmful to eyes, lungs and other organs. Cumulative poison. Store away from ignition sources. Use in fume hood if possible.
Millon's reagent	T	3	–	–	Poisonous. See mercury compounds.
Morpholine	T	2	3	0	Flammable. Irritating to skin, eyes and respiratory system.
Nitric acid (concentrated)	T	3	0	0	Strong oxidant. Contact with combustible materials may cause fires. Causes severe burns. Store in cool place away from oxidizing materials and organic acids or bases.

Nitrites	T	–	–	–	Contact with combustible material may cause fire. Harmful if taken internally or by inhalation of dust. Store away from combustible materials. Do not store on wood. See data sheets for potassium nitrite and sodium nitrite.
Oxalic acid	T	1	1	0	Harmful if taken internally; lachrymator. Caustic to skin and mucous membranes.
Penta-chlorophenol	T	dry 3 soln. 3	0 2	0 0	Serious risk of poisoning by inhalation, swallowing or skin contact; causes irritation of skin and eyes.
Perchloric acid and all perchlorates	E	acid 3 K 2 Na 2 Mg 1	0 0 0 0	3 2 2 0	Acid: extremely hazardous; contact with combustible material may cause fire; causes burns. Salts: explosive
Peroxides (except H_2O_2 30% or less)	E	benzoyl 1 Na 3	4 0	4 2	Benzoyl: Extreme risk of explosion by shock, friction, fire or other source of ignition. Irritating to skin and eyes. Sodium: Contact with combustible materials may cause fire. Causes severe burns.
Phenol	T	3	2	0	Toxic if taken internally. Causes burns. Very harmful by skin absorption.
Phenylthio-carbamide	T	–	–	–	The compound should not be tasted.
PTC paper	T	–	–	–	The paper should not be tasted.
Phosphine	T	–	–	–	Highly toxic by inhalation; extremely flammable.
Phosphorus, white or yellow	R	white 3 red 0	3 1	1 1	White phosphorus is spontaneously flammable in air. Serious risk of poisoning by inhalation or swallowing. White phosphorus must be stored under water. Red phosphorus should be stored in a cool place away from alkalies and oxidizing and reducing agents.
Phosphorus trichloride	R	3	0	2	Harmful vapor. Causes burns. Irritating to skin, eyes and respiratory system.

Picric acid	E	2	4	4	Risks of explosion by shock, friction, fire or other sources of ignition. Forms very sensitive explosive metallic compounds. Harmful if taken internally.
Potassium	R	3	1	2	Contact with water liberates highly flammable gases; causes burns.
Resorcinol	T	–	–	–	Irritating to skin and eyes.
Rhodanine	R	–	–	–	May explode on rapid heating.
Selenium and compounds	T	Se 3 Cpds 3	2 0	0 0	Serious risk of poisoning by inhalation or swallowing; irritating to skin, eyes, and respiratory system; danger of cumulative effects.
Sodium	R	3	1	2	Contact with water liberates highly flammable gases; causes burns. Store under mineral oil.
Stannic chloride	R	3	0	1	Causes burns; irritating to skin, eyes and respiratory system.
Strontium	T	–	–	–	Finely divided metal ignites in air.
Sulfamic acid	R	2	0	3	Irritating to skin and eyes.
Sulfuric acid (concentrated)	T	3	0	2	Causes severe burns; must be handled with caution; water must never be added to the concentrated acid. Store in cool place away from chlorates, nitrates, permanganates, powdered metals and organic compounds.
Thallium and compounds	T	3	–	–	Poisonous dust; serious risk of poisoning by inhalation or swallowing; danger of cumulative effects.
Toluene	R	2	3	0	Highly flammable; harmful vapor. Store in flammable solvent storage cabinet.
Xylene	R	2	3	0	Harmful vapor; harmful by skin absorption; flammable. Store in flammable solvent storage cabinet.

Carcinogenic (animal studies only)
Benzo[a]pyrene
Beryllium
Carbon tetrachloride
Chloroform
Dichlorobenzidine
Dimethylcarbamyl chloride
Dimethylhydrazine
Dimethyl sulfate
Ethylene dibromide
Hexachlorobutadiene
Hexamethylphosphoramide
4,4'-Methylene-bis (2-chloroaniline)
Methyl iodide
Nitrodiphenyl
Nitrosamines
N-Nitrosodimethylamine
N-Phenyl-beta-naphthylamine
Beta-propiolactone
Tannic acid
Vinyl bromide

Carcinogenic in humans
Acrylonitrile
Asbestos dust
Benzene
Benzidine
Chloromethylmethyl ether
Chromium compounds
Chromates
Naphthylamine
Vinyl chloride

Suspected Carcinogens (animal studies only)
Congo red (mutagenic)
Methylhydrazine
2-Nitropropane
o-Tolidine

Non-carcinogenic
Nitronaphthalene
Phenanthrene

Carcinogenicity Not Known
Nitrobenzene
Nitrosophenol
Propyleneimine

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ACETIC ANHYDRIDE $(CH_3CO)_2O$

FLAMMABLE. CAUSES BURNS

Hazard Rating:
Health 2; Fire 2; Reactivity 1.

Physical Properties:
Colorless liquid with strong acrid odor; bp 139°C.

Fire Hazard:
Flash point 54°C; explosive limits 3 – 10%; ignition temp 380°C. Extinguish fire with water spray, dry chemical foam or carbon dioxide.

Chemical Properties:
Reacts slowly with water to form acetic acid.

Hazardous Reactions:
Boric acid. Heating a mixture to 60°C may result in explosion.
Chromic acid. Strongly exothermic reaction occurs when the anhydride is added to an aqueous solution of chromium trioxide.
Glycerol and Phosphoryl chloride. Violent acylation of glycerol occurs using phosphoryl chloride as catalyst and in the absence of solvent.
Hydrogen peroxide. The mixture must be kept acid and an excess of the anhydride avoided to prevent the formation of highly explosive diacetyl peroxide.
Hypochlorous acid. Mixture may explode violently.
Metal Nitrates. Nitrating agents composed of the anhydride and copper and sodium nitrates cause violent reactions. Improved procedures have been published.
Nitric acid. Mixtures are detonatable.
Perchloric acid and Water. The anhydride is used to prepare anhydrous perchloric acid. It must be added slowly to the acid at about 10°C.
Potassium permanganate. Contact of the anhydride with $KMnO_4$ may cause explosion.
Water. Addition of water can cause vigorous acid–catalyzed hydrolysis and explosive boiling.

Physiological Properties and Health Hazards:
The vapor irritates the respiratory system and the eyes. The liquid burns the eyes severely and irritates and burns the skin causing blistering. Swallowing the liquid causes severe pain and vomiting.
Avoid contact of both the liquid and the vapor with eyes and skin.

Spillage Disposal:
Shut off all possible sources of ignition. Instruct others to keep at a safe distance. Wear breathing apparatus and gloves. Absorb on dry sodium carbonate and sand, shovel into bucket(s), transport to fume hood and dissolve in a large volume of water; leave to decompose before neutralizing and decanting water to waste, diluting greatly with running water. Site of spillage should be ventilated after washing thoroughly with water and soap.

Waste Disposal:
Place in a separate labelled container for disposal by burning.

Storage:
Store away from sources of ignition and strong oxidizers such as nitric acid, sodium peroxide.

Handling:
Wear safety glasses and gloves.

ACROLEIN (acraldehyde, acryl aldehyde, propenal) $CH_2=CH-CHO$

STORE UNDER REFRIGERATION. EXTREMELY FLAMMABLE. GIVES OFF POISONOUS VAPOR. IRRITATING TO SKIN, EYES AND RESPIRATORY SYSTEM.

Hazard Rating:
Health 3; Fire 3; Reactivity 2.

Physical Properties:
Colorless volatile liquid with pungent, choking odor; bp 52.5°C.

Fire Hazard:
Flash point −26°C; explosive limits 3−31%; ignition temp 278°C. Extinguish fire with dry chemical, foam or carbon dioxide.

Chemical Properties:
Somewhat soluble in water.

Hazardous Reactions:
Acids or Bases. Liable to polymerize violently, especially in contact with strong acidic or basic catalysts. Hydroquinone is added as stabilizer but may lose its effectiveness after a short storage time.

Physiological Properties and Health Hazards:
The vapor irritates all parts of the respiratory system and may cause unconsciousness. Short exposure may cause pain to the nose and eyes in addition to intense irritation. Assumed to have extremely poisonous and irritant action if taken by mouth.
Avoid breathing vapor. Prevent contact with eyes and skin.

Spillage Disposal:
Shut off all possible sources of ignition. Instruct others to keep at a safe distance. Wear breathing apparatus and gloves. Mop up with plenty of water and place in disposal container. Ventilate area well to evaporate remaining liquid and dispel vapor.

Waste Disposal:
Place in a separate labelled container for disposal by burning.

Storage:
Store under refrigeration in an air−tight container under nitrogen gas. Do not store uninhibited acrolein under any circumstances.

Handling:
Wear safety glasses. Work in fume hood.

ACRYLIC ACID

$CH_2=CHCOOH$

FLAMMABLE. CAUSES BURNS. IRRITATING TO SKIN, EYES AND RESPIRATORY SYSTEM.

Hazard Rating:
Health 3; Fire 2; Reactivity 2.

Physical Properties:
Colorless solid and liquid with acrid odor; mp 14°C; bp 141°C.

Fire Hazard:
Flash point 50°C; ignition temp 438°C. Extinguish fire with water spray, dry powder, carbon dioxide or vaporizing liquids.

Chemical Properties:
Miscible with water. Polymerizes.

Hazardous Reactions:
Uninhibited acid polymerizes exothermally at ambient temperature and a violent reaction or explosion may occur.

Physiological Properties and Health Hazards:
Liquid or strong solutions severely irritate the skin, eyes and respiratory system. Swallowing would cause extreme irritation.
Avoid breathing vapor. Prevent contact with skin and eyes.

Spillage Disposal:
Shut off all possible sources of ignition. Wear face shield and gloves. Cover with sodium carbonate. Mix and add water. Mop up with plenty of water and run to waste, diluting greatly with running water. Ventilate area well to evaporate remaining liquid and dispel vapor.

Waste Disposal:
Place in a separate labelled container for disposal by burning.

Storage:
Store in cool, well ventilated cupboard.

Handling:
Wear safety glasses.

ACRYLONITRILE (vinyl cyanide) $CH_2=CHCN$

HUMAN CARCINOGEN. HIGHLY FLAMMABLE. SERIOUS RISK OF POISONING BY INHALATION OR SWALLOWING. GIVES OFF POISONOUS VAPOR. LIGHT SENSITIVE.

Physical Properties:

Colorless volatile liquid with ethereal odor; bp 77.3°C.

Fire Hazard:

Vapor forms explosive mixtures with air. Flammable limits 3–17%. Flash point 0°C. Dilute solutions are also hazardous. Extinguish fires with dry chemical or carbon dioxide.

Chemical Properties:

1 part dissolves in about 15 parts water at 25°C.

Hazardous Reactions:

Tends to polymerize violently so it must never be stored uninhibited, in light or close to bases.

Acids. Vigorous reaction with sulfuric or nitric acids. Small quantities of acid may neutralize the inhibitor (aqueous ammonia).

Bases. Violent polymerization in contact with bases.

Bromine. Violent polymerization in the presence of bromine, possibly due to catalysis by hydrogen bromide.

Initiators. Free radical polymerization initiated by azoisobutyronitrile, benzoyl peroxide or di-*tert*-butyl peroxide may be explosive.

Silver nitrate. May polymerize violently in the presence of solid silver nitrate.

Physiological Properties and Health Hazards:

Vapor may cause dizziness, nausea and unconsciousness. Contact of liquid with skin may cause dermatitis. Swallowing or absorption through the skin leads to poisoning. Prolonged breathing of vapor may result in jaundice.

Avoid inhalation of vapor. Avoid contact with skin and eyes.

Spillage Disposal:

Shut off all possible sources of ignition. Instruct others to keep at a safe distance. Wear breathing apparatus and gloves.

Absorb on paper. Allow to evaporate on glass dish in hood. Dispose of paper by burning. Ventilate area well to evaporate remaining liquid and dispel vapor.

Waste Disposal:

Wear long rubber gloves, laboratory apron or coat. Work in fume hood.

Cautiously and slowly add to an excess of sodium hydroxide and calcium hypochlorite solution to produce a cyanate. After 24 hours flush down the drain with excess water.

Package Lots. Place in a separate labelled container for disposal.

ALUMINUM CHLORIDE ANHYDROUS $AlCl_3$

STORE IN COOL, DRY AREA PROTECTED FROM LIGHT. CAUSES BURNS. IRRITATING TO SKIN, EYES AND RESPIRATORY SYSTEM.

Hazard Rating:
Health 3; Fire 0; Reactivity 2.

Physical Properties:
Yellow or off-white pieces, granules or powder, volatilizes without melting; fumes in air.

Chemical Properties:
Violently decomposed by water, with the formation of hydrogen chloride.

Hazardous Reactions:
Spontaneous decomposition may occur on long storage and can result in an explosion on opening the container.
Benzoyl chloride and Naphthalene. A violent reaction occurs if $AlCl_3$ is added below the melting point of the mixture.
Ethylene oxide. Polymerizes violently in the presence of $AlCl_3$.
Lewis Acids. In the absence of a diluent (carbon disulfide), aluminum trichloride explodes violently with sulfuric acid and Lewis acids.
Nitrobenzene. Mixtures react violently at 120°C possibly due to the formation and polymerization of *o*- and *p*-chloronitrosobenzenes.
Nitrobenzene and Phenol. Mixtures react violently at 120°C.
Sodium borohydride. Contact of borohydride solution with solid $AlCl_3$ can lead to ignition of hydrogen.
Water. Violent reaction with water.

Physiological Properties and Health Hazards:
Dust irritates mucous membranes and causes painful eye burns. Interaction with moisture on the skin results in heat and acid burns. Swallowing causes severe burns.
Avoid breathing dust. Prevent contact with skin and eyes.

Spillage Disposal:
Wear goggles and gloves. Mix with sand and dry sodium carbonate, shovel into dry bucket, transport to a fume hood and add, a little at a time, to a large quantity of water. After the reaction is complete, run to waste diluting greatly with running water.

Waste Disposal:
In the fume hood, carefully mix with DRY sodium bicarbonate. Slowly and *cautiously* add to a large volume of water. Wash down the drain with excess water.

Storage:
Store with mineral acids. Keep container sealed.

Handling:
Wear safety glasses and gloves. Use the fume hood.

Program References:
Keys to Chemistry: 10-3, 11-2.

ALUMINUM HYDRIDE AlH_3

FLAMMABLE IN MOIST AIR. REACTS VIOLENTLY WITH WATER.

Physical Properties:

Colorless, nonvolatile solid.

Hazardous Reactions:

May decompose explosively at room temperature; ignites in air.

Carbon dioxide, Methyl ethers. Decomposes violently in dimethyl or di(2-methoxyethyl) ethers if CO_2 is present in the solution. If $AlCl_3$ is also present, the decompositon is explosive.

Tetrazoles. Complexes of AlH_3 and a variety of tetrazoles are explosive.

Spillage Disposal:

Wear rubber gloves, fire proof clothing, face shield. Work from behind body shield where possible. Keep available pulverized dolomite or dry graphite for fire fighting. Eliminate all sources of ignition. Mix with dry sand to avoid or stop fire. Place in fume hood. Follow waste disposal procedure.

Waste Disposal:

For reaction mixtures:

In a fume hood, mix with dry sand to avoid or stop fire. *Cautiously* and slowly add DRY butyl or *iso*propyl alcohol until reaction ceases. Later add water until last of hydride is destroyed. Scoop the solid into a large container. Neutralize with 6*M* HCl. Let settle. Decant and flush to sewer with excess of water. Discard sand.

For packaged lots:

Place in separate labelled container for disposal.

Storage:

Protect containers from physical damage. Store in a cool, *dry* place with other reducing agents and isolated from other chemicals.

Handling:

Wear safety glasses and gloves.

AMMONIUM DICHROMATE $(NH_4)_2Cr_2O_7$

HUMAN CARCINOGEN. CONTACT WITH COMBUSTIBLE MATERIAL MAY CAUSE FIRE. HARMFUL IF TAKEN INTERNALLY. FLAMMABLE.

Physical Properties:
Bright orange–red crystals. Dec. 180°C.

Fire Hazard:
Self–sustaining decomposition occurs at 225°C with swelling, release of heat and nitrogen gas, leaving Cr_2O_3. Extinguish with water.

Chemical Properties:
Very soluble in water; oxidizing agent.

Hazardous Reactions:
Decomposes and ignites on heating to 190°C. Green Cr_2O_3 is emitted and explosion occurs if confined.

Physiological Properties and Health Hazards:
Dust irritates respiratory tract and eyes. Swallowing causes internal irritation and damage. Prolonged exposure to the dust may cause skin ulceration, liver and kidney damage and ultimately cancer. Avoid breathing dust. Avoid contact with eyes and skin.

Spillage Disposal:
Cover with sodium thiosulfate or sodium bisulfite. Scoop slurry into a container of water and neutralize. Wash down drain with excess water.
Site of spillage should be washed thorouoghly to remove all oxidant, which is liable to render any organic matter (particularly wood, paper and textiles) with which it comes into contact, dangerously combustible when dry. Clothing wetted with the solution should be washed thoroughly.

Waste Disposal:
Add to a large volume of concentrated solution of sodium thiosulfate, sodium bisulfite or a ferrous salt and acidify with 3*M* H_2SO_4. When reduction is complete add sodium carbonate or dilute hydrochloric acid to neutralize the solution. Wash into drain with large excess of water.

Program References:
Physical Science: A Problem Solving Approach (Carter). Problem 14–4; omit volcano experiment.
Physical Science: Interaction of Matter and Energy (Heath and McNaughton), 11.2, p. 221; omit.
Physical Science: An Introductory Study (Andrews, Wolfe and Eix), 1.5, p. 8; omit heating ammonium dichromate; use 1.4 only.
Ibid., 6.6, p. 136; substitute potassium permanganate.

AMMONIUM HYDROXIDE (solution) NH_4OH

CAUSES BURNS. IRRITATING TO SKIN, EYES AND RESPIRATORY SYSTEM

Hazard Rating:

NH_3 gas: Health 2; Fire 1; Reactivity 0.

Physical Properties:

Ammonia solution is commonly supplied to laboratories as a 35% solution in water (0.88 specific gravity). In warm weather this strong solution develops pressure in its bottle and the cap must be released with care.

Colorless liquid; intense, pungent, suffocating odor.

Physiological Properties and Health Hazards:

Vapor irritates the respiratory system. Solution causes severe eye and skin burns. Swallowing the solution results in severe internal damage.

Avoid breathing vapor. Prevent contact with skin and eyes.

Spillage Disposal:

Instruct others to keep at a safe distance. Wear breathing apparatus and gloves (and rubber boots or overshoes if spillage is large). Mop up with plenty of water and run to waste diluting greatly with water.

Waste Disposal:

Wear rubber gloves, large face shield, laboratory coat. Work in fume hood. Pour into large tank of water and neutralize. Transfer to sewer with large excess of water.

Storage:

Store in a cool, well ventilated cupboard, separate from other chemicals, especially oxidizing agents such as the halogens or chlorates. Only small quantities of concentrated solutions should be stored.

Handling:

Wear safety glasses and gloves. Work in the fume hood. The concentrated solution can develop pressure in the bottle on storage, thus the cap must be released slowly.

Program References:

Physical Science: Interaction of Matter and Energy (Heath and McNaughton), Chapter 7.9, p. 149.

Biology: Investigations in Biology (Benson *et al.*), Investigation 38.

Alchem 10: C3.

Alchem 20: I3(D).

Alchem 30: N1(D), N3(D).

Keys to Chemistry: 2-2, 3-1, 4-1, 4-4, 6-5, 9-1, 10-3, 11-1, 11-2.

Chemistry: Experiments and Principles, (Davis *et al.*), Ex. 20, 21, 30, 31, 44, 45.

AMMONIUM OXALATE $H_4NOOCCOONH_4$

HARMFUL IF TAKEN INTERNALLY

Physical Properties:
Colorless crystals or granules.

Chemical Properties:
Soluble in water.

Physiological Properties and Health Hazards:
Swallowing results in severe internal pain and collapse.

Spillage Disposal:
Wear face shield or goggles and gloves. Mop up with plenty of water and run to waste, diluting greatly with water.

Waste Disposal:
Place in a separate labelled container for disposal by burning.

Storage:
Store in general chemical stores.

Handling:
Wear safety glasses.

Program References:
Biology: Investigations in Biology (Benson *et al.*), Investigation 8.
Chemistry: Experiments and Principles (Davis *et al.*), Ex. 20.

ANILINE $C_6H_5NH_2$

TOXIC IN CONTACT WITH SKIN. GIVES OFF POISONOUS VAPOR.

Hazard Rating:
Health 3; Fire 2; Reactivity 0.

Physical Properties:
Colorless to brown liquid; bp 185°C.

Fire Hazard:
Flash point 70°C. Flammable limits: 1.3% to (unknown). Extinguish with water, dry chemical or carbon dioxide.

Chemical Properties:
Immiscible with water.

Hazardous Reactions:
Dibenzoyl peroxide. Addition of 1 drop of aniline to 1 g of the peroxide results in mildly explosive decomposition.
Oxidants. Aniline is oxidized vigorously by perchloric acid, fuming nitric acid, sodium peroxide and ozone.

Physiological Properties and Health Hazards:
Breathing vapor causes headache, drowsiness, cyanosis, mental confusion and finally convulsions. Liquid damages eyes and if swallowed results in similar effects to breathing vapor. Prolonged breathing of vapor or skin contact disturbs the nervous system and the blood.
Avoid breathing vapor. Avoid contact with eyes and skin.

Spillage Disposal:
Wear breathing apparatus and gloves. Mix with sand and shovel mixture into a suitable vessel. Disperse in an excess of dilute hydrochloric acid (1 volume concentrated acid diluted with 2 volumes of water). Allow to stand for 24 hours, then run acid extract to waste, diluting greatly with running water. Sand can be treated as normal waste.

Waste Disposal:
Place in a separate, labelled container for disposal by burning.

Storage:
Store in a cool, dry place away from oxidizing agents and mineral acids.

Handling:
Wear safety glasses. Use fume hood when using large quantities.

ANTIMONY COMPOUNDS (water-soluble) Sb

POISON. IRRITATING TO SKIN, EYES AND RESPIRATORY SYSTEM

Hazard Rating:

Antimony: Health 3; Fire 2; Reactivity 0.
Antimony pentachloride: Health 3; Fire 0; Reactivity 1.
Antimony pentafluoride: Health 3; Fire 0; Reactivity 1.
Antimony pentasulfide: Health 0; Fire 1; Reactivity 1.

Physical Properties:

Most soluble antimony compounds are colorless crystals or powder; the pentachloride is a colorless to yellow fuming liquid with an offensive smell.

Hazardous Reactions:

ANTIMONY COMPOUNDS (TRIVALENT)
Perchloric acid. Trivalent antimony compounds tend to form explosive mixtures with perchloric acid when hot.

ANTIMONYL PERCHLORATE $SbOClO_4$.
This chemical decrepitates when heated above 60°C.

ANTIMONY PENTAFLUORIDE SbF_5
Phosphorus. Phosphorus ignites in contact with antimony pentafluoride.

ANTIMONY SULFIDE Sb_2S_3
Air. When the crystalline form of antimony trisulfide is heated in air, it burns with a blue flame.
Chlorates. Antimony sulfide reacts with incandescence with chlorates of cadmium, magnesium or zinc.

ANTIMONY TRIBROMIDE $SbBr_3$.
Potassium or Sodium. A mixture of antimony tribromide with potassium or sodium produces a strong explosion on impact.

Physiological Properties and Health Hazards:

All soluble antimony compounds must be considered to be poisonous when taken by mouth. Some compounds cause skin irritation and dermatitis. If taken by mouth, soluble antimony compounds may cause burning of the mouth and throat, choking, nausea and vomiting. Stibine, which may be formed by the action of acidic reducing agents on antimony-containing materials, is an extremely poisonous gas, causing blood destruction and damage to liver and kidneys. Insoluble antimony compounds, such as the oxide and sulfide, are not toxic.

Spillage Disposal:

Follow waste disposal procedure.

Waste Disposal:

Place solution in an evaporating dish in the fume hood. When all the liquid has evaporated, place the residue in a labelled sealed container for disposal.

Storage:

Store crystalline compounds in poison cupboard. Store antimony pentachloride in fume hood.

Handling:

Wear safety glasses and gloves. Work in fume hood.

Program References:

Antimony: Alchem 10: A2; omit sample of antimony.
Antimony sulfide: Keys to Chemistry: 6-6; omit Sb^{3+} as cation, no Sb_2S_3 formed.
Antimony trichloride: Keys to Chemistry: 6-6, 11-2; omit Sb^{3+} as cation, no substitute.

ARSENIC COMPOUNDS As

POISON. SERIOUS RISK OF POISONING BY INHALATION OR SWALLOWING. DANGER OF CUMULATIVE EFFECTS. IRRITATING TO SKIN, EYES AND RESPIRATORY SYSTEM.

Hazard Rating:

Arsenic: Health 3; Fire 2.
Arsenic Sulfide: Health 3; Fire 1; Reactivity 0.

Physical Properties:

Most arsenic compounds are colorless powders or crystals. They include arsenites and arsenates of many metals; syrupy arsenic acid and arsenic trichloride are liquids. All must be considered to be extremely poisonous. The metal itself has not been recognized as a noteworthy hazard.

Hazardous Reactions:

ARSENIC SULFIDES AsS_2, As_2S_3, As_2S_5
Chlorates. Arsenic sulfides react with incandescence with chlorates of cadmium, magnesium or zinc.
Hydrogen peroxide. Hydrogen peroxide reacts vigorously with arsenic trisulfide.

ARSENIC TRICHLORIDE $AsCl_3$.
Potassium or Sodium. A mixture of arsenic trichloride with potassium or sodium produces a strong explosion on impact.

ARSENIC TRIFLUORIDE AsF_3
Phosphorus trioxide. Reaction is very violent.

ARSENIC TRIIODIDE AsI_3.
Potassium or Sodium. A mixture of arsenic triiodide with potassium or sodium produces a strong explosion on impact.

ARSENIC TRIOXIDE As_2O_3
Fluorine. Fluorine reacts violently with arsenic trioxide.

ARSINE AsH_3
Chlorine. When chlorine is bubbled into arsine, each bubble produces a flame.
Nitric acid. Fuming nitric acid reacts explosively with arsine.

Physiological Properties and Health Hazards:

The inhalation of dust or fumes irritates the mucous membranes and leads to arsenical poisoning. Certain compounds, especially the trichloride and arsenic acid, irritate the eyes and skin, and absorption causes poisoning. If swallowed, arsenic compounds irritate the stomach severely and affect the heart, liver and kidneys; nervousness, thirst, vomiting, diarrhea, cyanosis and collapse are symptoms.
Chronic Effects. The inhalation of small concentrations of dust or fumes over a long period will cause poisoning; skin contact over a long period may cause ulceration.
Do not inhale dust or fumes. Prevent contact with skin and eyes.

Waste Disposal:

Place solution in an evaporating dish in the fume hood. When all the liquid has evaporated, place the residue in a labelled sealed container for disposal.

Storage:

Store in poison cupboard.

Handling:

Wear safety glasses and gloves. Avoid breathing dust. Use fume hood.

Program References:

Alchem 10: A2; omit sample of arsenic.

ASBESTOS DUST (native Ca-Mg silicate)

HUMAN CARCINOGEN

Physical Properties:
Fine, slender, flaxy fibers.

Physiological Properties and Health Hazards:
Occupational exposure to the dust may cause cancer after a long latent period.

AZIDES

EXPLOSIVE

METAL AZIDES

See alphabetical listing for
SODIUM AZIDE

This large and well-documented group of explosive compounds contains some which are widely used industrially.

ORGANIC AZIDES

See alphabetical listing for
PHENYL AZIDE

Careful and small-scale handling of organic azides, which are usually heat-or shock-sensitive compounds of varying degrees of stability is necessary. The presence of more than one azido group, particularly if on the same atom (C or N) greatly reduces the stability.

DISPOSAL

The following reaction can be used to decompose small amounts of organic azides.

$$R\text{-}N_3 \xrightarrow[\text{Raney Ni}]{N_2H_4.H_2O} R\text{-}NH_2 + N_2$$

BARIUM CHLORIDE $BaCl_2$

POISON. HARMFUL IF TAKEN INTERNALLY

Hazard Rating:
Health 2; Fire 0.

Physical Properties:
Crystals, granules or powder, mp 963°C.

Physiological Properties and Health Hazards:
Swallowing results in nausea, stomach pains, vomiting and diarrhea.

Spillage Disposal:
Mop up with water and run the solution to waste, diluting greatly with running water.

Waste Disposal:
Place solution in an evaporating dish in the fume hood. When all the liquid has evaporated, place the residue in a labelled sealed container for disposal.

Storage:
Store in general chemical stores.

Handling:
Wear safety glasses and gloves.

Program References:
Challenges to Science – Life Science, (Smallwood), Chapter 13, p. 252.
Physical Science: A Problem Solving Approach, (Carter) Problem 14.4.
Physical Science Investigations, (Carter) 7–1, p. 200, 202.
Biology: Investigations in Biology (Benson *et al.*), Investigations 8, 38.
Alchem 10: C3,
Alchem 20: J1.
Alchem 30: K1.
Keys to Chemistry: 10–2, 10–3, 11–1, 11–2.
Chemistry: Experiments and Principles, (Davis *et al.*), Ex. 11, 17, 18.

BARIUM COMPOUNDS Ba^{++}

POISON HARMFUL IF TAKEN INTERNALLY

Physical Properties:
Practically all barium compounds are colorless crystals or powders

Hazardous Reactions:
See also individual barium compounds.

BARIUM PERCHLORATE $Ba(ClO_4)_2$
Explosive alkyl perchlorates are formed on distillation of mixtures with alcohols.

BARIUM PEROXIDE BaO_2
Acetic anhydride. Formation of acetyl peroxide from mixtures of barium peroxide and acetic anhydride results in a violent explosion.
Hydrogen sulfide. Hydrogen sulfide may ignite in contact with barium peroxide.
Hydroxylamine. Aqueous hydroxylamine ignites on contact with barium peroxide.
Metals. Powdered aluminum or magnesium ignite on contact with the peroxide.
Non-Metal Oxides. Barium peroxide incandesces when heated in a stream of CO_2 or SO_2.
Performic acid. Addition of barium peroxide to 90% acid causes violent decomposition.
Propane. Heating barium peroxide under propane results in a violent exothermic reaction.
Wood. Friction of the peroxide between wooden surfaces can cause ignition of the wood.

Physiological Properties and Health Hazards:
All soluble barium compounds (i.e., all compounds except barium sulfate) are poisonous if swallowed and cause nausea, stomach pains, vomiting and diarrhea.

Spillage Disposal:
The sulfate may be brushed up and treated as normal refuse. Soluble barium salts should be mopped up with water and the solution run to waste, diluting greatly with running water.

Waste Disposal:
Place solution in an evaporating dish in the fume hood. When all the liquid has evaporated, place the residue in a labelled sealed container for disposal.

Storage:
Store in general chemical stores.

Handling:
Wear safety glasses and gloves.

Program References:
Barium carbonate: Keys to Chemistry: 20,
Chemistry: Experiments and Principles, (Davis *et al.*), Ex. 22.
Barium chromate: Chemistry: Experiments and Principles, (Davis *et al.*), Ex. 18, 20, 30.

BARIUM HYDROXIDE $Ba(OH)_2$

POISON. HARMFUL IF TAKEN INTERNALLY.

Hazard Rating:
Health 2.

Physical Properties:
Monohydrate: white powder; octahydrate: transparent crystals or white masses. mp 78°C.

Hazardous Reactions:
Chlorinated Rubber. Chlorinated rubber reacts violently or explosively with barium hydroxide.

Physiological Properties and Health Hazards:
Poisonous causing nausea, stomach pains, vomiting and diarrhea if swallowed.

Spillage Disposal:
Mop up with water and run the solution to waste, diluting greatly with running water.

Waste Disposal:
Place solution in an evaporating dish in the fume hood. When all the liquid has evaporated, place the residue in a labelled sealed container for disposal.

Storage:
Store in general chemical stores.

Handling:
Wear safety glasses and gloves.

Program References:
Biology: Investigations in Biology (Benson *et al.*), Investigation 9.
Chemistry: Experiments and Principles, (Davis *et al.*), Ex. 17, 31(D), 38.

BARIUM NITRATE $Ba(NO_3)_2$

POISON. HARMFUL IF TAKEN INTERNALLY

Hazard Rating:
Health 1; Fire 0; Reactivity 0.

Physical Properties:
Crystals or powder, mp about 590°C.

Hazardous Reactions:
Aluminum, Potassium nitrate, Sulfur and Water. A paste consisting of the above with barium nitrate explodes.
Aluminum-Magnesium Alloy. A mixture of the metal powder with barium nitrate is extremely sensitive to friction or impact.

Physiological Properties and Health Hazards:
Poisonous causing nausea, stomach pains, vomiting and diarrhea if swallowed.

Spillage Disposal:
Mop up with water and run the solution to waste, diluting greatly with running water.

Waste Disposal:
Place solution in an evaporating dish in the fume hood. When all the liquid has evaporated, place the residue in a labelled sealed container for disposal.

Storage:
Store in general chemical stores.

Handling:
Wear safety glasses and gloves.

Program References:
Keys to Chemistry: 5–2, 10–3, 11–2.
Chemistry: Experiments and Principles, (Davis *et al.*), Ex. 17, 18, 20, 22, 30.

BARIUM SULFATE $BaSO_4$

WATER INSOLUBLE THEREFORE DOES NOT CAUSE POISONING

Physical Properties:
Fine, heavy, odorless powder or polymorphous crystals, decomposes above 1600°C.

Hazardous Reactions:
Aluminum Powder. Heating of an intimate mixture of barium sulfate and aluminum powder results in violent or explosive reduction of the sulfate.

Physiological Properties and Health Hazards:
Water-insoluble, so not considered to be poisonous. May contain soluble barium salts as impurities which are poisonous when swallowed.

Spillage Disposal:
Mop up with water and run the solution to waste, diluting greatly with running water.

Waste Disposal:
Place solution in an evaporating dish in the fume hood. When all the liquid has evaporated, place the residue in a labelled sealed container for disposal.

Storage:
Store in general chemical stores.

Handling:
Wear safety glasses and gloves.

Program References:
Biology: Investigations in Biology (Benson *et al.*), Investigation 9.
Alchem 20: 12.
Chemistry: Experiments and Principles, (Davis *et al.*), Ex. 17, 18, 20, 22, 38.

BENZAL CHLORIDE (benzylidene chloride) $C_6H_5CHCl_2$

IRRITATING TO SKIN, EYES AND RESPIRATORY SYSTEM

Physical Properties:
Colorless liquid; bp 205°C, fumes in air.

Chemical Properties:
Immiscible with water.

Physiological Properties and Health Hazards:
Vapor irritates respiratory system and eyes. Liquid irritates eyes and skin. Both may cause conjunctivitis. Swallowing would cause internal damage.
Avoid breathing vapor. Avoid contact with eyes and skin.

Spillage Disposal:
Instruct others to keep at a safe distance. Wear breathing apparatus and gloves. Absorb spills on paper towels. Place in a hood to evaporate. Dispose by burning towel. Site of spillage should be washed thoroughly with water and soap.

Waste Disposal:
Place in a separate, labelled container for disposal by burning.

Storage:
Store in general chemical stores.

Handling:
Wear safety glasses. Use fume hood.

BENZENE (benzol; coal naphtha) C_6H_6

HUMAN CARCINOGEN. EXTREMELY FLAMMABLE. GIVES OFF VERY POISONOUS VAPOR. DANGER OF CUMULATIVE EFFECTS.

Physical Properties:
Colorless, volatile liquid with characteristic odor; bp 80.1°C.

Fire Hazard:
Flash point −11°C; explosive limis 1.4–8%; ignition temp 562°C. Extinguish fire with foam, dry powder, or vaporizing liquids.

Hazardous Reactions:
Oxidants. The solid complex formed between benzene and silver perchlorate may explode on crushing. Permanganic acid, produced by reaction of permanganates with sulfuric acid explodes on contact with benzene. Mixtures of nitric acid and benzene containing about 84% acid are highly sensitive to detonation.
Benzene ignites on contact with concentrated hydrogen peroxide or with sodium peroxide and water.

Physiological Properties and Health Hazards:
Vapor irritates eyes and mucous membranes and causes dizziness and headache; high concentration may cause unconsciousness. Swallowing or absorption through the skin results in severe poisoning. Prolonged breathing of the vapor may cause severe or even fatal blood disease.
Avoid inhalation of vapor. Prevent contact with skin and eyes.

Spillage Disposal:
Shut off all possible sources of ignition. Instruct others to keep at safe distance. Wear breathing apparatus and gloves. Absorb onto paper towels. Evaporate in glass dish in fume hood. Dispose of paper by burning. Site of spillage should be washed thoroughly with water and soap.

Waste Disposal:
Place in non-halogenated solvent disposal container for disposal by burning.

Program References:
Alchem 20: H2; ;substitute toluene.
Keys to Chemistry: 4–1; substitute toluene.
Ibid., 7–2; substitute toluene.
Ibid, 9–6; omit as unknown, do not substitute toluene, it is too high boiling.
Chemistry: Experiments and Principles, (Davis *et al.*), Ex. 39; omit benzene, toluene is already being used here.
Investigations of Cells and Organisms, A Laboratory Study in Biology (Abramoff and Thomson), Ex. 23, p. 69; substitute toluene.

BENZENESULFONIC ACID $C_6H_5SO_3H$

CAUSES BURNS. IRRITATING TO SKIN AND EYES.

Physical Properties:

Anhydrous mp 50–51°C (also reported as 65–66°C). Sesquihydrate is deliquescent plates, tablets, mp 43–44°C.

Chemical Properties:

Freely soluble in water.

Physiological Properties and Health Hazards:

Solutions irritate skin and eyes and may cause burns. Swallowing results in internal irritation and damage.
Avoid contact with skin and eyes.

Spillage Disposal:

Wear face shield or goggles, and gloves. Spread sodium carbonate liberally over the spillage and mop up cautiously with plenty of water. Run to waste, diluting greatly with running water.

Waste Disposal:

Place in a separate labelled container for disposal by burning.

Storage:

Store in general chemical stores away from moisture and amines.

Handling:

Wear safety glasses and gloves.

BENZIDINE AND SALTS

$H_2N(C_6H_4)_2NH_2$

HUMAN CARCINOGEN.

Physical Properties:
White or reddish crystalline powder, mp 115–120°C (slow heating), 128°C (rapid heating).

Chemical Properties:
One gram dissolves in 2500 mL cold water, 107 mL boiling water.

Physiological Properties and Health Hazards:
Breathing the dust or its absorption through the skin may result in bladder tumors.

Spillage Disposal:
Wear butyl rubber gloves, plastic laboratory coat, self–contained breathing apparatus.
On skin and clothing. Wash skin with strong soap solution immediately. Rinse thoroughly. Contaminated clothing should be removed, dried, and washed with strong soap solution, or destroyed. It may be necessary to destroy shoes by burning.
Small spills. Brush solids onto paper. Wash site with strong soap solution. Place in a separate labelled container for disposal by burning.

Waste Disposal:
Place in a separate labelled container for disposal by burning.

BENZO[a]PYRENE $C_{20}H_{12}$

ANIMAL CARCINOGEN

Physical Properties:
Yellowish plates or needles, mp 179°C.

Chemical Properties:
Practically insoluble in water.

Waste Disposal:
Place in a separate labelled container for disposal by burning.

BERYLLIUM (metal) Be

ANIMAL CARCINOGEN

Physical Properties:
Gray metal mp 1287°C.

Chemical Properties:
Oxide film renders metal resistant to attack by acid.

Hazardous Reactions:
Carbon dioxide, Nitrogen. Powdered beryllium ignites on heating in a mixture of CO_2 and N_2.
Halocarbons. Powdered beryllium in carbon tetrachloride or trichloroethylene will ignite on heavy impact.
Halogens. Beryllium incandesces in fluorine or chlorine when warm.
Phosphorus. Beryllium incandesces when heated with phosphorus.

Spillage Disposal:
Wear rubber gloves, self-contained respirator, laboratory coat (wash after each job). Brush solid onto paper. Place in large stoppered wide-mouth bottle for disposal. Wash site with soap solution.

Waste Disposal:
Place solution in an evaporating dish in the fume hood. When all the liquid has evaporated, place the residue in a labelled sealed container for disposal.

BROMINE Br_2

GIVES OFF VERY POISONOUS VAPOR. CAUSES SEVERE BURNS.

Hazard Rating:
Health 4; Fire 0; Reactivity 0.

Physical Properties:
Dark reddish-brown fuming liquid; bp 59.47°C.

Chemical Properties:
Slightly soluble in water.

Hazardous Reactions:
Acetone. Excess of bromine causes sudden violent reaction.
Acrylonitrile. Violent polymerization may result.
Ammonia. Explosive red oil formed on cooling to −95°C after interaction at room temperature.
Diethyl ether. Violent reaction may occur on addition of bromine.
N,N-Dimethylformamide. Highly exothermic reaction to yield hydroxymethylene-dimethylammonium bromide.
Ethanol and Phosphorus. Dangerous mixture formed.
Hydrogen. Mixture may be explosive.
Metal Acetylides and Carbides. Mono- and di-alkali metal acetylides and copper acetylides ignite in liquid bromine or its vapor. Alkaline earth, iron, uranium and zirconium carbides ignite in the vapor.
Metal Azides. Vapor with silver or sodium azide forms explosive bromine azide.
Metals. Impact sensitive mixtures are formed from lithium or sodium in dry bromine. Potassium, germanium, antimony and rubidium ignite in bromine vapor. Violent reaction occurs with aluminum, mercury, or titanium.
Methanol. Vigorously exothermic reaction on mixing the liquids.
Non-Metal Hydrides. At room temperature violent explosion and ignition occurs with silane and its homologs and with germane.
Rubber. Violent reaction with natural rubber; slower reaction with synthetic rubbers.
Trialkylboranes. Lower homologs tend to ignite in bromine.

Physiological Properties and Health Hazards:
The vapor irritates all parts of the respiratory system. The vapor severely irritates the eyes and mucous membranes. The liquid burns the skin and eyes. If taken by mouth, severe local burns and internal damage would result.
Prevent breathing of vapor. Prevent contact with eyes and skin.

Spillage Disposal:
Instruct others to keep at a safe distance. Wear breathing apparatus and gloves. Spread dry sodium carbonate liberally over the spillage and mop up cautiously with plenty of water. Run to waste diluting greatly with running water.

Waste Disposal:
Add product to a large excess of water. Slowly add sodium bisulfite. *Cautiously* add a few drops of acid. When reaction subsides, neutralize and wash down the drain with excess water.

Storage:
Store in a cool, dry area out of direct sunlight and separate from combustible or organic material.

Handling:
Wear safety glasses and gloves. Use fume hood.

Program References:
Alchem 10: A2; omit sample of bromine, might substitute commercially supplied bromine water.
Alchem 20: H2; use commercially supplied bromine in trichlorotrifluoroethane or

substitute commercially supplied bromine water. Requires shaking.
Chemistry: Experiments and Principles, (Davis *et al.*), Ex. 35; use commercially supplied bromine water.
Ibid., Ex. 39; use commercially supplied bromine in trichlorotrifluoroethane.

CADMIUM COMPOUNDS Cd^{++}

HARMFUL BY INHALATION. HARMFUL IF TAKEN INTERNALLY.

Hazard Rating:
Cadmium: Health 3; Fire 2; Reactivity 0.

Chemical Properties:
Chloride, nitrate and sulfate soluble in water; oxide and carbonate insoluble.

Hazardous Reactions:
CADMIUM AMIDE $Cd(NH_2)_2$
Rapid heating may result in explosion.
Water. Violent reaction with water.

CADMIUM AZIDE $Cd(N_3)_2$
The dry solid explodes on heating or with light friction. Contact of cadmium rods with aqueous hydrogen azide caused a violent explosion.
Sodium azide. A mixture of saturated solutions of cadmium and sodium azides explodes several hours after mixing.

CADMIUM CHLORATE $Cd(ClO_3)_2$.
Sulfides. Explosive interaction with copper sulfide; incandescent interaction with antimony(III), arsenic(III), tin(II) and tin(IV) sulfides.

CADMIUM HYDRIDE CdH_2
Sudden decomposition of the hydride occurs at 2°C forming a residue of pyrophoric cadmium.

CADMIUM OXIDE CdO
Magnesium. Cadmium oxide is reduced explosively on heating with magnesium.

CADMIUM PHOSPHIDE Cd_3P_2
Nitric acid. Reaction with concentrated acid is explosive.

CADMIUM PROPIONATE $Cd(C_2H_5COO)_2$
The salt exploded during drying in an oven at 60–100°C.

CADMIUM SELENIDE CdSe
Explosion may occur on heating cadmium and selenium together unless the particles are smaller than a critical size.

Physiological Properties and Health Hazards:
Dust (usually cadmium or cadmium oxide) irritates the lungs. Swallowing any cadmium compound causes choking, stomach pains, vomiting and diarrhea. Prolonged exposure to the dust may result in lung and kidney damage.
Avoid inhaling dust.

Spillage Disposal:
Cadmium compounds are not so toxic as to present serious disposal problems. The insoluble compounds can be mixed with wet sand, swept up and treated as normal waste. The soluble salts can be mopped up with water and run to waste, diluting greatly with water.

Waste Disposal:
Place solution in an evaporating dish in the fume hood. When all the liquid has evaporated, place the residue in a labelled sealed container for disposal.

Storage:
Store in general chemical stores.

Handling:
Wear safety glasses and gloves.

Program References:

Cd strips: Alchem 30: M3 – substitute iron strips or lead strips.

$CdSO_4$: Alchem 30: M3 – substitute 0.1*M* ferrous sulfate or 0.1*M* lead nitrate.

CALCIUM CARBIDE (calcium acetylide) CaC_2

EXPLOSIVE GAS FORMED ON CONTACT WITH WATER

Hazard Rating:
Health 1; Fire 4; Reactivity 2.

Physical Properties:
Grayish-black, irregular lumps or orthorhombic crystals, mp 2300°C.

Fire Hazard:
Liberates acetylene on contact with water or moisture. Use dry chemical for fire fighting.

Chemical Properties:
Decomposed by water with evolution of acetylene leaving a residue of lime.

Hazardous Reactions:
Non-ferrous tools must be used to open containers.
Halogens. Incandesces with Cl_2, Br_2 and I_2 at 245, 350 and 305°C respectively.
Hydrogen chloride. Incandesces on warming.
Iron(III) chloride, Iron(III) oxide. Powdered mixture burns violently when ignited.
Lead difluoride. Incandesces on contact at room temperature.
Magnesium. Mixture incandesces on warming.
Methanol. Very vigorous reaction with boiling methanol.
Silver nitrate. Precipitates the highly sensitive explosive, silver acetylide, from silver nitrate solutions.
Sodium peroxide. A mixture is explosive.
Stannous chloride. A mixture can be ignited with a match.
Water. Forms explosive mixture due to generation of acetylene.

Spillage Disposal:
Wear rubber gloves, safety glasses, laboratory coat.
Spills. Transfer to fume hood and dispose of the material cautiously by adding it very slowly to a large volume of water. Allow to stand for 24 hours and run to sewer with excess water.

Waste Disposal:
Place in a separate labelled container for disposal by burning.

Storage:
Store away from sources of ignition, completely separate from water.

Handling:
Wear safety glasses and gloves. Handle on a dry bench away from water.

CARBON DISULFIDE CS_2

EXTREMELY FLAMMABLE. GIVES OFF VERY POISONOUS VAPOR.

Hazard Rating:
Health 2; Fire 3; Reactivity 0.

Physical Properties:
Colorless to yellow liquid, with unpleasant odor; bp 46.5°C.

Fire Hazard:
Flash point −30°C; explosive limits 1.3–50%; ignition temp 90°C. Extinguish fire with foam, dry powder, carbon dioxide or vaporizing liquids.

Chemical Properties:
Immiscible with water; decomposes on long standing.

Hazardous Reactions:
Many fires and explosions have resulted by ignition of the vapor from liquid poured down laboratory sinks. Highly volatile and highly flammable. The vapor may ignite on contact with steam pipes, especially if rusted.
Air and Rust. A mixture of carbon disulfide and air can explode in the presence of rust.
Halogens. Mixtures of chlorine and carbon disulfide may explode in the presence of iron.
Metal Azides. Mixtures of carbon disulfide and aqueous solutions of metal azides form explosive metal azidodithioformates.
Metals. Aluminum powder ignites in carbon disulfide vapor. A mixture of carbon disulfide with K–Na alloy or with Na itself are powerful explosives. Zinc incandesces in carbon disulfide.
Oxidants. A mixture of carbon disulfide and nitric oxide may explode.

Physiological Properties and Health Hazards:
Vapor irritates the eyes and produces drowsiness, eventually resulting in unconsciousness. Liquid irritates the eyes and is poisonous if swallowed. Prolonged exposure to the vapor results in disruption of the nervous system.
Avoid breathing vapor.

Spillage Disposal:
Shut off all possible sources of ignition. Instruct others to keep at a safe distance. Wear breathing apparatus and gloves. Absorb on paper towels. Place in an evaporating dish in the fume hood to evaporate. Dispose by burning towels. Ventilate area of spillage thoroughly to dispel vapor.

Waste Disposal:
Place in a separate labelled container for disposal by burning.

Storage:
Store in general flammable solvent storage cabinet away from sources of ignition. Area should be well ventilated.

Handling:
Wear safety glasses and gloves. Use fume hood.

Program References:
Physical Science: A Problem–Solving Approach (Carter) Problem 14–2; omit.
Physical Science: Interaction of Matter and Energy (Heath and McNaughton) 3.9, p. 77; omit.
Keys to Chemistry: 10–2; omit.

CARBON TETRACHLORIDE (tetrachloromethane) CCl_4

GIVES OFF POISONOUS VAPOR.

Hazard Rating:
Health 3; Fire 0; Reactivity 0.

Physical Properties:
Heavy, colorless liquid with a characteristic odor; bp 76.7°C.

Chemical Properties:
Immiscible with water. When used for extinguishing fires, phosgene, which is very poisonous, is liable to be formed.

Hazardous Reactions:
Aluminum chloride, Triethylaluminum. A mixture of triethyldialuminum trichloride exploded when warmed to room temperature.
Benzoyl peroxide, Ethylene. Mixtures of ethylene and carbon tetrachloride can explode at elevated temperatures on initiation with benzoyl peroxide.
N,N-Dimethylformamide. Iron may catalyze a very exothermic and sometimes violent reaction between carbon tetrachloride and dimethylformamide.
Metals. Heating Al powder with carbon tetrachloride to 152°C may cause an explosion. The cleaning of barium lumps under carbon tetrachloride resulted in a violent reaction. Mixtures of K or K–Na with carbon tetrachloride are extremely shock sensitive. A paste of Zn and carbon tetrachloride will burn readily after ignition.
Potassium tert-butoxide. Addition of drops of carbon tetrachloride to 1.5 g of potassium *tert*–butoxide resulted in ignition after 1 min.

Physiological Properties and Health Hazards:
Vapor irritates the eyes and may cause headache, mental confusion, nausea, vomiting and finally coma. Liquid irritates the eyes and if swallowed causes nausea, vomiting and damage to the liver, kidneys, heart and nervous system. Small doses may result in death. Prolonged exposure to the vapor may cause vomiting, bronchitis and jaundice.
Avoid breathing vapor. Avoid contact with skin and eyes.

Spillage Disposal:
Instruct others to keep at a safe distance. Wear breathing apparatus and gloves. Absorb on paper towels and evaporate in a hood. Dispose of towels by burning. Ventilate area of spillage thoroughly to dispel vapor.

Waste Disposal:
Place in halogenated solvent disposal container.

Storage:
Store in cool, dry, well ventilated area protected from light.

Handling:
Wear safety glasses and gloves. Use fume hood.

Program References:
Alchem 10: B2; substitute dichloromethane or 1,1,1–trichloroethane.
Ibid., D1; substitute water.
Alchem 20: H2; substitute trichlorotrifluoroethane which gives violet color with iodine.
Alchem 30: M1(D); substitute trichlorotrifluoroethane which gives violet color with iodine.
Keys to Chemistry: 3–1(D); substitute dichloromethane.
Ibid., 4–1; substitute dichloromethane or 1,1,1–trichloroethane.
Ibid., 7–1; substitute dichloromethane or 1,1,1–trichloroethane.
Ibid., 11–1; substitute trichlorotrifluoroethane which gives violet color with iodine.
Ibid., 11–2; substitute trichlorotrifluoroethane which gives violet color with iodine.

CHLORATES

EXPLOSIVE WHEN MIXED WITH COMBUSTIBLE MATERIAL. HARMFUL IF TAKEN INTERNALLY

Fire Hazard:
Powerful oxidizing agents. Form explosive mixtures with combustible material.

See POTASSIUM CHLORATE
SODIUM CHLORATE

CHLORINE Cl_2

TOXIC BY INHALATION IRRITATING TO SKIN, EYES AND RESPIRATORY SYSTEM.

Hazard Rating:
Health 3; Fire 0; Reactivity 0.

Physical Properties:
Greenish-yellow gas with irritating odor; bp -34.05°C.

Chemical Properties:
Soluble in water.

Hazardous Reactions:
tert-Butanol. During the preparation of *tert*-butyl hypochlorite by chlorination of *tert*-butanol, the temperature must be kept below 20°C to prevent explosion. Hypochlorite solution may be used instead of chlorine.
Carbon disulfide. The presence of traces of iron will catalyze the chlorination of carbon disulfide to carbon tetrachloride resulting in an explosion.
Cobalt(II) chloride and Methanol. Passage of chlorine into a solution of cobalt chloride, bipyridyl and lithium chloride in methanol resulted in an explosion and ignition of the methanol probably due to formation of methyl hypochlorite.
Dibutyl phthalate. Mixture of the ester and chlorine in a bomb exploded at 118°C.
Diethyl ether. Ether may ignite on contact with chlorine.
Glycerol. Mixture of glycerol and liquid chlorine in a bomb exploded at 70-80°C.
Hydrocarbons. Methane and chlorine explode in the presence of mercury oxide. Mixtures of chlorine and ethylene explode in sunlight or in the presence of mercury or silver oxides. Explosions occur between liquid chlorine and gasoline or a naphtha-sodium hydroxide mixture.
Hydrocarbons and Lewis Acids. In the chlorination of hydrocarbons in the presence of Lewis acid catalysts, large volumes of HCl are released if the catalyst is added to the chlorine hydrocarbon mixture. The catalyst should always be mixed with the hydrocarbon before addition of chlorine.
Hydrogen. Mixtures of hydrogen and chlorine over the range 5-89% of hydrogen are explosive and can be initiated by sparks, radiant energy or catalysts.
Iron(III) chloride and Monomers. Chlorination of styrene in carbon tetrachloride at 50°C resulted in a violent reaction which was catalyzed by ferric chloride.
Metal Hydrides. Potassium, sodium and copper hydrides ignite in chlorine.
Metals. Aluminum, calcium powder, copper foil, iron wire, manganese powder and potassium ignite in dry chlorine gas as do powdered antimony, bismuth and germanium. Magnesium, sodium and zinc ignite in the moist gas. Thorium, tin and uranium ignite on warming.
Methanol. Traces of metallic impurities in methanol can lead to an explosion and ignition of the methanol on introduction of chlorine.
Nitrogen Compounds. Mixtures of ammonia and chlorine are explosive; hydrazine and hydroxylamine ignite in chlorine. Formation of the dangerously explosive nitrogen trichloride is possible during chlorination of alkylthiuronium salts. Aziridine readily forms the explosive *N*-chloro derivative. Chlorination of sulfamic acid or acidic ammonium chloride solutions can give the powerfully explosive oil, nitrogen trichloride.
Non-Metals. Boron, activated carbon, silicon and phosphorus ignite in gaseous chlorine.
Phenylmagnesium bromide. The solid which formed on treatment of the Grignard reagent with chlorine exploded when shaken.
Silicon Oils. A mixture of liquid chlorine and silicone oils in a bomb exploded on heating.
Sodium hydroxide. Addition of liquid chlorine to 20% sodium hydroxide solution resulted in a violent reaction.
Steel. Dry steel wool ignites in chlorine at 50°C.
Sulfides. Diarsenic disulfide, diboron trisulfide and mercuric sulfide ignite in chlorine.
Synthetic Rubber. Natural and synthetic rubbers burn in liquid chlorine.
Water. Some mixtures of chlorine and water can be ignited by a spark.

Physiological Properties and Health Hazards:
Gas irritates eyes and lungs causing severe damage.
Avoid breathing gas.

Spillage Disposal:

Wear rubber gloves, laboratory coat and self-contained breathing apparatus. If the valve is leaking because it cannot be closed (a common occurrence), the gas can be bubbled through a reducer (sodium sulfite) and excess sodium bicarbonate solution. Be sure to include a trap in the line to prevent the solution being sucked back into the cylinder. If this cannot be done, the cylinder should be placed in or adjacent to a fume hood and left to bleed off.

If the leak is in the valve assembly, a plastic bag can be fastened over the head of the cylinder which can then be taken outside or to a fume hood.

Waste Disposal:

Wear rubber gloves, laboratory coat and self-contained breathing apparatus. Bubble the gas through a large volume of concentrated solution of reducer (sodium sulfite, sodium bisulfite). When reduction is complete, neutralize and wash into drain with a large excess of water.

Storage:

Store cylinders upright and tightly secured in fume hood or well ventilated area.

Handling:

Always use the fume hood.

Program References:

Alchem 10: A2; omit sample of chlorine gas.

Alchem 30: M1(D); chlorine gas formed in the reaction, use fume hood.

Keys to Chemistry: 11-1; substitute solution of Clorox (250 mL) in distilled water (500 mL) and 6*M* hydrochloric acid (35 mL) diluted to make 1 liter.

Ibid., 11-2; use Clorox solution (see above) for chlorine water; chlorine gas formed in test for ClO_3^-, substitute test: to 1 mL of the ClO_3^- solution, add 3-4 drops of 0.01 *M* $AgNO_3$ solution and 1-2 drops of 0.2 *M* $NaNO_2$; the appearance of a white precipitate (AgCl) confirms ClO_3^-.

Chemistry: Experiments and Principles, (Davis *et al.*), Ex. 35; use Clorox solution (see above) for chlorine water.

Physical Science, An Introductory Study (Andrews, Wolfe and Eix), 7.2, p. 172; omit procedure C.

CHLOROFORM (trichloromethane) $CHCl_3$

HARMFUL VAPOR

Hazard Rating:
Health 2; Fire 0; Reactivity 0.

Physical Properties:
Colorless volatile liquid with a characteristic odor; bp 61–62°C.

Chemical Properties:
Immiscible with water.

Hazardous Reactions:
Acetone, Alkali. In the presence of potassium hydroxide or calcium hydroxide, chloroform and acetone react vigorously to form 1,1,1-trichloro-2-hydroxy-2-methylpropane.
Metals. Mixtures of K, Na or K–Na alloys form impact-sensitive explosives.
Potassium tert-butoxide. Contact of potassium *tert*-butoxide with chloroform vapor or liquid results in ignition.
Sodium, Methanol. Addition of sodium to an inadequately cooled mixture of chloroform and methanol results in an explosion.
Sodium hydroxide and Methanol. A mixture of chloroform and methanol reacts vigorously in the presence of small quantities of sodium hydroxide. A closed container of the mixture will explode.
Sodium methoxide. A mixture of solid sodium methoxide, methanol and chloroform may explode if the sodium methoxide is added in one portion.

Physiological Properties and Health Hazards:
Vapor irritates eyes and causes drowsiness, headache, nausea, vomiting and unconsciousness. Liquid irritates eyes and causes poisoning if swallowed.
Avoid breathing vapor. Avoid contact with eyes.

Spillage Disposal:
Instruct others to keep at a safe distance. Wear breathing apparatus and gloves. Absorb on paper towels and allow $CHCl_3$ to evaporate in a hood. Dispose of towels by burning. Site of spillage should be washed thoroughly with water and soap or detergent.

Waste Disposal:
Place in halogenated solvent disposal container.

Storage:
Store in a cool, dry, well ventilated area protected from light.

Handling:
Wear safety glasses and gloves. Use fume hood.

Program References:
Biology BSCS Green version, 1.4; substitute 1,1,1-trichloroethane.

CHLOROMETHYL METHYL ETHER CH_3OCH_2Cl

HUMAN CARCINOGEN

Physical Properties:
Liquid bp 55–57°C.

Hazardous Reactions:
Peroxide Formation. Ether on long standing in contact with air and exposed to light may contain peroxides, especially if stored in clear glass. **Explosions have occurred when caps or stoppers were turned.**

Spillage Disposal:
Wear rubber gloves, large heavy face shield (if in doubt use body shield also), self–contained breathing apparatus.
Eliminate all sources of ignition and flammables. Absorb on paper towel. Evaporate from an iron pan in a hood. Allow time for vapors to completely escape the hood vents, then burn the paper.
If large spill, absorb on much more paper or vermiculite and allow complete evaporation from all surfaces. Use same precaution before burning paper.

Waste Disposal:
Check for peroxides (see following) and if absent, place waste in disposal containers for burning.

A SIMPLE TEST FOR PEROXIDES IN ETHERS
1. Put 10 mL of the solution to be tested in test tube.
2. Add spatulaful of KI or NaI.
3. Add 5 mL of distilled water.
4. Add 5 mL of solvent.
5. Add a few drops of HCl or H_2SO_4.

If color is *yellow or faint orange* peroxide concentration is negligible.
If color is *purple or dark violet* peroxides are present.

If peroxides are present, do not handle. Contact disposal authorities.

CHROMATES CrO_4^{2-}

HUMAN CARCINOGENS AS DUST.
CONTACT WITH COMBUSTIBLE MATERIAL MAY CAUSE FIRE.
HARMFUL IF TAKEN INTERNALLY.

See: POTASSIUM CHROMATE
SODIUM CHROMATE

Program References:

Physical Science: Interaction of Matter and Energy (Heath and McNaughton): 11.2, p. 221; omit.

Aluminum chromate: Chemistry: Experiments and Principles, (Davis *et al.*), Ex. 18. Formed as dilute solutions; dispose of as described under waste disposal of chromium and compounds.

Barium chromate: Chemistry: Experiments and Principles, (Davis *et al.*), Ex. 18, 20, 30. Formed as dilute solutions; dispose of as described under waste disposal of chromium and compounds.

Calcium chromate: Chemistry: Experiments and Principles, (Davis *et al.*), Ex. 20. Formed as dilute solutions; dispose of as described under waste disposal of chromium and compounds.

Lead chromate: Chemistry: Experiments and Principles, (Davis *et al.*), Ex. 21. Formed as dilute solutions; dispose of as described under waste disposal of chromium and compounds.

Magnesium chromate: Chemistry: Experiments and Principles, (Davis *et al.*), Ex. 20. Formed as dilute solutions; dispose of as described under waste disposal of chromium and compounds.

Mercury chromate: Chemistry: Experiments and Principles, (Davis *et al.*), Ex. 21. Formed as dilute solutions; dispose of as described under waste disposal of chromium and compounds.

Silver chromate: Chemistry: Experiments and Principles, (Davis *et al.*), Ex. 18, 21, 23. Formed as dilute solutions; dispose of as described under waste disposal of chromium and compounds.

Strontium chromate: Chemistry: Experiments and Principles, (Davis *et al.*), Ex. 18. Formed as dilute solutions; dispose of as described under waste disposal of chromium and compounds.

CHROMIUM AND COMPOUNDS Cr

CARCINOGENIC AS DUST

Physical Properties:
Steel-gray lustrous metal, mp 1900°C.

See also:
AMMONIUM DICHROMATE
CHROMATES
CHROMIUM DIACETATE
DICHROMATES
POTASSIUM CHROMATE
POTASSIUM DICHROMATE
SODIUM CHROMATE
SODIUM DICHROMATE

Physiological Properties and Health Hazards:
Chromium(III) compounds show little or no toxicity.

Spillage Disposal:
Wear rubber gloves, safety glasses, laboratory coat. Work in hood or wear a respirator. Cover spill with sodium carbonate or sodium bicarbonate. Mix and spray with water. If effervescent wait until reaction is complete. Scoop into a large beaker and cautiously add equal volume of calcium hypochlorite (reaction may be vigorous). Add more water, stir, and allow to stand for one hour. Dilute and neutralize the oxidized solution and transfer to the drain with excess of water.

Waste Disposal:
Mix with equal volume of sodium carbonate and add water to form a slurry in a large container. Add calcium hypochlorite. Add more water if necessary and let stand two hours. Neutralize the oxidized solution. Wash down drain with large excess of water.

Storage:
Store in general chemical stores.

Handling:
Wear safety glasses and gloves.

Program References:
Chromium: Alchem 10: A2; use in form other than finely divided dust, e.g., as ore or granules.
Chromium(III) acetate: Chemistry: Experiments and Principles, Ex. 46; omit experiment.
Chromium(III) chloride: Keys to Chemistry: 11-2; use commercially supplied 0.2 *M* solution.
Chromium(III) nitrate: Keys to Chemistry: 5-2; use commercially supplied 0.1 *M* solution.
Ibid., 11-2; use commercially supplied 0.2 *M* solution.
Chromium(III) sulfate: Keys to Chemistry: 11-2; use commercially supplied 0.2 *M* solution.
Chemistry, Experiments and Principles (Davis *et al.*), Ex. 38; use commercially supplied 0.1 *M* solution.
Chromic acid: Investigations in Biology (Benson), Investigation 40; use commercially supplied 0.1 *M* solution.

CHROMIUM DIACETATE (chromous acetate, chromium(II) acetate) $Cr(C_2H_3O_2)_2$

CARCINOGENIC AS DUST

Physical Properties:

Monohydrate: deep red powder.
Anhydrous salt: brown.

Chemical Properties:

Slightly soluble in cold water, readily soluble in hot. Easily oxidized.

Hazardous Reactions:

Anhydrous salt is pyrophoric in air. In lower oxygen concentrations, it chars slowly.

Spillage Disposal:

Wear rubber gloves, safety glasses, laboratory coat. Work in hood or wear a respirator. Cover spill with sodium carbonate or sodium bicarbonate. Mix and spray with water. If effervescent wait until reaction is complete. Scoop into a large beaker and cautiously add equal volume of calcium hypochlorite (reaction may be vigorous). Add more water, stir, and allow to stand for one hour. Dilute and neutralize the oxidized solution and transfer to the drain with excess of water.

Waste Disposal:

Mix with equal volume of sodium carbonate and add water to form a slurry in a large container. Add calcium hypochlorite. Add more water if necessary and let stand two hours. Neutralize the oxidized solution. Wash down the drain with large excess of water.

CONGO RED (CI Direct Red 28) $C_{32}H_{22}N_6Na_2O_6S_2$

SUSPECTED ANIMAL CARCINOGEN

Physical Properties:
Brownish-red powder. Congo red paper is paper charged with a 0.1% aqueous solution of Congo red.

Chemical Properties:
Soluble in water.

Waste Disposal:
Place in a separate labelled container for disposal by burning.

Program References:
Biology: Investigations of Cells and Organisms, A Laboratory Study in Biology, (Abramoff and Thomson), Ex. 14, p. 41.
Biology: Investigations in Biology (Benson *et al.*), Investigations 6, 13, 36.

Substitute Congo Red paper or use commercially supplied 2% solution.

CYANIDES (water soluble) CN^-

POISONOUS. SERIOUS RISK OF POISONING BY INHALATION, SWALLOWING OR SKIN CONTACT. CONTACT WITH ACIDS LIBERATES A TOXIC GAS.

See alphabetical listing for:

POTASSIUM CYANIDE
SODIUM CYANIDE

Hazard Rating:
Na, Ca, K: Health 3; Fire 0; Reactivity 0.

Physical Properties:
Colorless crystals or powders.

Chemical Properties:
Soluble in water; react with acids to generate hydrogen cyanide.

Physiological Properties and Health Hazards:
Soluble Cyanides. Cyanide salts and solutions of cyanides present considerably less risk than does hydrogen cyanide gas since they are dangerous only by ingestion and ingestion is unlikely to occur in significant quantities except by deliberate intention; poisoning by inhalation of these preparations is not a hazard. This however does not mean they should be treated without due circumspection. Solutions of over 1% strength should always be kept under strict control; those under 1% constitute, in practice, little danger but always demand careful handling.

If ingestion of cyanide solution does take place, amyl nitrite should be administered as for the gas and the casualty rapidly moved to hospital.

Cyanides and their solutions, and hydrogen cyanide liberated from these by the action of acids, are extremely poisonous. Both the cyanide solutions and the gas can be absorbed through the skin. Whatever the route of absorption, severe poisoning may result. The early warning symptoms of poisoning are general weakness and heaviness of the arms and legs, increased difficulty in breathing, headache, dizziness, nausea, vomiting, and these may be rapidly followed by pallor, unconsciousness, cessation of breathing, and death.

Waste Disposal:
Add product to an excess of a strong alkaline solution containing calcium hypochlorite. (Caution! A vigorous reaction may occur.) Let mixture stand overnight.
Wash down the drain with excess water.

Storage:
Store in poison cupboard.

Handling:
Wear safety glasses and gloves. Always use in fume hood.

DIBUTYL ETHER (n-butyl ether) $C_4H_9OC_4H_9$

FLAMMABLE. MAY FORM EXPLOSIVE PEROXIDES.

Hazard Rating:
Health 2; Fire 3; Reactivity 0.

Physical Properties:
Colorless liquid, bp 142°C.

Chemical Properties:
Insoluble in water. May form explosive peroxides on exposure to light and air. These should be decomposed before the ether is distilled.

Fire Hazard:
Flash point 25°C; explosive limits 1.5 – 7.6%; ignition temp. 194°C. Extinguish fire with dry chemical, carbon dioxide, or foam.

Hazardous Reactions:
Peroxides formed during storage can be removed by percolation through alumina.
Chlorine and Ammonium sulfate. Mixture may explode.

Physiological Properties and Health Hazards:
The vapor is somewhat irritating to the respiratory system. The liquid irritates the eyes, and is considered to present some hazard by skin absorption.
Avoid breathing vapor. Avoid contact with skin and eyes.

Spillage Disposal:
Shut off all possible sources of ignition. Instruct others to keep at a safe distance. Wear breathing apparatus and gloves. Absorb on sand, shovel into bucket(s) and transport to safe open area for controlled burning. Ventilate site of spillage well to evaporate remaining liquid and dispel vapor.

Waste Disposal:
Check for peroxides (see following) and if absent, place waste in disposal containers for burning.

A SIMPLE TEST FOR PEROXIDES IN ETHERS
1. Put 10 mL of the solution to be tested in test tube.
2. Add spatulaful of KI or NaI.
3. Add 5 mL of distilled water.
4. Add 5 mL of solvent.
5. Add a few drops of HCl or H_2SO_4.

If color is *yellow or faint orange* peroxide concentration is negligible.
If color is *purple or dark violet* peroxides are present.

If peroxides are present, do not handle. Contact disposal authority.

Storage:
Store in flammable solvent storage cabinet.

Handling:
Wear safety glasses.

3,3'-DICHLOROBENZIDINE $(H_2N-C_6H_3Cl)_2$

ANIMAL CARCINOGEN

Physical Properties:
Needles, mp 132–133°C.

Chemical Properties:
Almost insoluble in water.

Spillage Disposal:
Wear butyl rubber gloves, protective laboratory coat, self-contained breathing apparatus, protective shoes.
On skin. Wash with strong soap solution immediately. Rinse well.
Contaminated gloves, clothing, shoes. Remove and clean at once or destroy by burning.
Small spills on tables or floor. Sweep solid spills onto paper. Package for disposal by burning. Wash the site thoroughly with strong soap solution.
Large spills. Absorb or mix with vermiculite, sodium bicarbonate or sand. Package this for disposal by burning. Wash site thoroughly as above.

Waste Disposal:
Place in a separate labelled container for disposal by burning.

DICHROMATES $Cr_2O_7^{2-}$

HUMAN CARCINOGENS AS DUST. CONTACT WITH COMBUSTIBLE MATERIAL MAY CAUSE FIRE. HARMFUL IF TAKEN INTERNALLY

Physical Properties:
Generally yellow or orange–red crystals or powders.

Chemical Properties:
Usually soluble in water.

Hazardous Reactions:
See: AMMONIUM DICHROMATE
POTASSIUM DICHROMATE
SODIUM DICHROMATE

Physiological Properties and Health Hazards:
Dust irritates respiratory tract and eyes. Swallowing results in poisoning and internal damage. Prolonged exposure to dust may cause skin ulceration, damage to liver and kidneys and even cancer.
Avoid breathing dust. Avoid contact with eyes and skin.

Spillage Disposal:
Cover with sodium thiosulfate or sodium bisulfite. Scoop slurry into a container of water and neutralize. Wash down drain with excess water.
Site of spillage should be washed thoroughly to remove all oxidant, which is liable to render any organic matter (particularly wood, paper and textiles) with which it comes into contact, dangerously combustible when dry. Clothing wetted with the solution should be washed thoroughly.

Waste Disposal:
Add to a large volume of concentrated solution of sodium thiosulfate, sodium bisulfite or a ferrous salt and acidify with $3M$ H_2SO_4. When reduction is complete add sodium carbonate or dilute hydrochloric acid to neutralize the solution. Wash into drain with large excess of water.

Program References:
Barium dichromate: Chemistry: Experiments and Principles, (Davis *et al.*), Ex. 30; formed in dilute solution, dispose of as described under waste disposal, above.

DIETHYL ETHER (ethyl ether; ethoxyethane) $(C_2H_5)_2O$

EXTREMELY FLAMMABLE. MAY FORM EXPLOSIVE PEROXIDES. HARMFUL VAPOR.

Hazard Rating:
Health 2; Fire 4; Reactivity 1.

Physical Properties:
Colorless liquid; bp 34°C.

Fire Hazard:
Flash point −45°C; extinguish fire with dry powder or carbon dioxide.

Chemical Properties:
Immiscible with water; liable to form explosive peroxides on exposure to air and light.

Hazardous Reactions:
Air. Forms explosive peroxides in air and light.
Oxidizing Agents. May react explosively.

Physiological Properties and Health Hazards:
Breathing vapor causes drowsiness and, in high concentration, unconsciousness. Continued exposure leads to symptoms resembling chronic alcoholism.

Spillage Disposal:
Shut off all possible sources of ignition. Instruct others to keep at a safe distance. Wear breathing apparatus and gloves. Absorb on sand, shovel into bucket(s) and transport to safe open area for controlled burning. Ventilate site of spillage well to evaporate remaining liquid and dispel vapor.

Waste Disposal:
Check for peroxides (see following) and if absent, place waste in disposal containers for burning.

A SIMPLE TEST FOR PEROXIDES IN ETHERS
1. Put 10 mL of the solution to be tested in test tube.
2. Add spatulaful of KI or NaI.
3. Add 5 mL of distilled water.
4. Add 5 mL of solvent.
5. Add a few drops of HCl or H_2SO_4.

If color is *yellow or faint orange* peroxide concentration is negligible.
If color is *purple or dark violet* peroxides are present.

If peroxides are present, do not handle. Contact disposal authorities.

Storage:
Store in flammable solvent storage cabinet.

Handling:
Wear safety glasses.

DIMETHYLCARBAMYL CHLORIDE (dimethylcarbamoyl chloride) $(CH_3)_2NCOCl$

ANIMAL CARCINOGEN

Physical Properties:
Liquid bp 165–167°C.

Chemical Properties:
Reacts with water or steam to produce toxic and corrosive fumes.

Physiological Properties and Health Hazards:
Lachrymator, irritant. Skin exposure causes tumors in animals.

Waste Disposal:
Carefully mix with dry sodium bicarbonate. Dilute slowly with water and wash down the drain with excess water.

1,1-DIMETHYLHYDRAZINE $(CH_3)_2NNH_2$

ANIMAL CARCINOGEN

Physical Properties:
Hygroscopic, mobile liquid. Fumes in air and gradually turns yellow, bp 63.9°C.

Fire Hazard:
Flammable.

Chemical Properties:
Miscible with water.

Hazardous Reactions:
Oxidants. Ignites on contact with nitric acid, hydrogen peroxide and nitrogen dioxide among other oxidants.

Physiological Properties and Health Hazards:
Highly corrosive and irritating to skin, eyes, mucous membranes. Convulsant poison.

Spillage Disposal:
Wear rubber gloves, self-contained breathing apparatus. Impervious clothing recommended. Body shield should be available.
Eliminate all sources of ignition and flammables.
On skin or clothing. Wash skin immediately. Remove contaminated clothing at once.
Large spills. Collect the liquid with an aspirator such as used for recovering spilled mercury. Empty into a large beaker and neutralize with dilute sulfuric acid. Wash to drain with excess water. Wash site with soap and water.

Waste Disposal:
Place in a separate labelled container for disposal by burning.

DIMETHYL PHTHALATE $C_6H_4(COOCH_3)_2$

TOXIC IF TAKEN INTERNALLY. IRRITATING TO RESPIRATORY SYSTEM.

Hazard Rating:
Health 2; Fire 1; Reactivity 0.

Physical Properties:
Colorless, odorless, viscous liquid, mp 5.5°C; bp 283.7°C.

Fire Hazard:
Flash point 146°C.

Chemical Properties:
Insoluble in water. Miscible with organic solvents.

Physiological Properties and Health Hazards:
Breathing vapor may cause coughing and paralysis. Liquid irritates the skin. Swallowing causes internal irritation, vomiting, diarrhea and coma.

Spillage Disposal:
Eliminate all sources of ignition. Wear rubber gloves and safety glasses. Absorb on paper. Place in a labelled container for disposal by burning.

Waste Disposal:
Place in a separate, labelled container for disposal by burning.

Storage:
Store in general chemical stores.

Handling:
Wear safety glasses.

DIMETHYL SULFATE (methyl sulfate) $(CH_3)_2SO_4$

GIVES OFF POISONOUS VAPOR. CAUSES BURNS. IRRITATING TO SKIN, EYES AND RESPIRATORY SYSTEM.

Physical Properties:
Colorless oily liquid; bp 188°C with decomposition.

Fire Hazard:
Flash point 83°C, autoignition temp 188°C. Extinguish with water, dry chemical, foam or carbon dioxide.

Chemical Properties:
Somewhat soluble in water.

Hazardous Reactions:
Ammonia. Violent reaction with concentrated aqueous ammonia.
Tertiary Bases. In absence of solvent reaction may be explosive.

Physiological Properties and Health Hazards:
Vapor causes severe irritation of respiratory system, with possible severe lung injury after a latent period. Vapor and liquid irritate or burn the eyes severely after a latent period, resulting in temporary or permanent dimming of vision. The vapor or liquid may blister the skin and skin absorption may result in severe poisoning after a latent period. Extremely poisonous and irritant if taken by mouth.
Prevent inhalation of vapor. Prevent contact with skin and eyes.

Spillage Disposal:
Instruct others to keep at a safe distance. Wear breathing apparatus and gloves. Absorb on sand, shovel into buckets and transport to fume hood. Site of spillage should be washed thoroughly with water and soap. Follow waste disposal procedure.

Waste Disposal:
Place in a separate, labelled container for disposal by burning.

DIOXANE (diethylene dioxide; diethylene oxide; dioxan) $C_4H_8O_2$

HIGHLY FLAMMABLE. MAY FORM EXPLOSIVE PEROXIDES. HARMFUL VAPOR.

Hazard Rating:
Health 2; Fire 3; Reactivity 1.

Physical Properties:
Colorless liquid; bp 101°C; faint pleasant odor.

Fire Hazard:
Flash point 12°C; explosive limits 2–22%; ignition temp 180°C. Extinguish fire with water spray, dry powder, carbon dioxide or vaporizing liquid.

Chemical Properties:
Soluble in water and the usual organic solvents. Liable to form explosive peroxides on exposure to light and air which should be decomposed before the ether is distilled to small volume.

Hazardous Reactions:
Air. Like all other ethers, dioxane forms explosive peroxides on exposure to air and these may be hazardous if the dioxane is distilled. Since dioxane is miscible with water, peroxides should be removed by passing the liquid through a column of activated alumina. The alumina should be washed with water or methanol before being discarded.

Physiological Properties and Health Hazards:
Vapor irritates mucous membranes and eyes and may lead to headache and drowsiness. High concentration of vapor or swallowing liquid may cause nausea and vomiting and injury to the kidney and liver.
Avoid breathing vapor.

Spillage Disposal:
Shut off all possible sources of ignition. Instruct others to keep at a safe distance. Wear breathing apparatus and gloves. Absorb on paper. Evaporate on an iron pan in a hood. Burn the paper. Ventilate area well to evaporate remaining liquid and dispel vapor.

Waste Disposal:
Check for peroxides (see following) and if absent, place waste in disposal containers for burning.

A SIMPLE TEST FOR PEROXIDES IN ETHERS
1. Put 10 mL of the solution to be tested in test tube.
2. Add spatulaful of KI or NaI.
3. Add 5 mL of distilled water.
4. Add 5 mL of solvent.
5. Add a few drops of HCl or H_2SO_4.

If color is *yellow or faint orange* peroxide concentration is negligible.
If color is *purple or dark violet* peroxides are present.

If peroxides are present, do not handle. Contact disposal authorities.

Storage:
Store in general flammable solvent storage cabinet away from oxidizing agents and sources of ignition.

Handling:
Wear safety glasses.

ETHERS

FLAMMABLE. MAY FORM EXPLOSIVE PEROXIDES.

See CHLOROMETHYL METHYL ETHER
DIETHYL ETHER
DIBUTYL ETHER
DIOXANE

ETHYLENE DIBROMIDE (1,2-dibromoethane) $BrCH_2CH_2Br$

ANIMAL CARCINOGEN. HARMFUL VAPOR. TOXIC IN CONTACT WITH SKIN.

Physical Properties:
Colorless liquid with sweetish chloroform–like odor, bp 131–132°C

Chemical Properties:
Soluble in 250 parts water.

Hazardous Reactions:
Magnesium. Reaction to give Grignard compounds may be violent.

Physiological Properties and Health Hazards:
Vapor irritates respiratory system and eyes. Liquid irritates eyes and skin. Swallowing or absorption through the skin results in nausea, vomiting and liver and kidney damage. Avoid breathing vapor. Avoid contact with skin and eyes.

Spillage Disposal:
Instruct others to keep at a safe distance. Wear breathing apparatus and gloves. Absorb spills on paper towels. Place in fume hood to evaporate. Dispose of paper by burning. Site of spillage should be washed thoroughly with water and soap.

Waste Disposal:
Place in halogenated solvent disposal container.

FLUORIDES F^-

TOXIC IF TAKEN INTERNALLY.

Hazard Rating:
Ammonium fluoride: Health 3; Fire 0; Reactivity 0.
Potassium fluoride: Health 3.
Sodium fluoride: Health 2; Fire 0; Reactivity 0.

Physical Properties:
Colorless crystals or powders.

Chemical Properties:
Soluble in water.

Hazardous Reactions:
See alphabetical listing for:

POTASSIUM FLUORIDE
SODIUM FLUORIDE

Physiological Properties and Health Hazards:
Dust irritates respiratory system, eyes and skin. Swallowing causes nausea, stomach pains, vomiting and diarrhea. Long-term exposure results in shortness of breath, cough and cyanosis.

Spillage Disposal:
Wear goggles and gloves. Sweep into beaker. Dilute with sufficient water. Add sodium carbonate. Mix, then neutralize with 6*M* hydrochloric acid. Wash down drain diluting greatly with running water.

Storage:
Store in poison cupboard.

Handling:
Wear safety glasses and gloves.

FORMALDEHYDE SOLUTION (formalin) HCHO

FLAMMABLE. SERIOUS RISK OF POISONING BY INHALATION OR SWALLOWING. CAUSES BURNS. IRRITATING TO SKIN, EYES AND RESPIRATORY SYSTEM

Hazard Rating:
Health 2; Fire 2; Reactivity 0.

Physical Properties:
Colorless, sometimes milky solution with pungent odor; bp 96°C.

Fire Hazard:
Flash point about 60°C.

Chemical Properties:
Miscible with water; the solution generally contains 37–41% formaldehyde and 10–15% methanol.

Hazardous Reactions:
Hydrogen peroxide. Mixtures of hydrogen peroxide and formaldehyde explode under initiation.
Magnesium carbonate. Shaking of formaldehyde with magnesium carbonate to neutralize any formic acid present produces carbon dioxide which may cause explosion of a sealed container.
Phenol. A runaway reaction may be encountered during the preparation of phenol–formaldehyde resins.

Physiological Properties and Health Hazards:
Vapor irritates respiratory system and the eyes. The liquid irritates the eyes severely and hardens the skin. Swallowing results in stomach pain, nausea, vomiting and finally loss of consciousness. Prolonged exposure to the vapor can result in laryngitis, bronchitis or bronchial pneumonia. Prolonged skin contact causes skin ulceration.
Avoid breathing vapor. Avoid contact with eyes and skin.

Spillage Disposal:
Shut off all possible sources of ignition. Wear face shield or goggles, and gloves.
Small Spills. Absorb on paper towel. Evaporate in fume hood and burn the paper.
Large Spills. Cover with sodium bisulfite ($NaHSO_3$). Add small amount of water and mix. Scoop into large beaker. After one hour wash down the drain with a large excess of water. Wash site with soap solution.

Waste Disposal:
Place in separate labelled container for disposal by burning.

Storage:
Store in flammable storage cabinet away from oxidizing agents or alkaline materials.

Handling:
Wear safety glasses and gloves. For large quantities, use the fume hood.

Program References:
Life Science: A Problem–Solving Approach (Carter) Prob. 7–4.
Challenges to Science–Life Science (Smallwood) Ch. 18, p. 356.
Biology BSCS Green version, 1.4, 3.1.

Substitute 70% ethanol in all above experiments.

Chemistry, Experiments and Principles (Davis *et al.*), Ex. 39; very small quantities of formaldehyde produced in the reaction.

HEXACHLOROBUTADIENE C_4Cl_6

ANIMAL CARCINOGEN

Physical Properties:
Autoignition temp 610°C.

Waste Disposal:
Place in a separate labelled container for disposal.

HEXAMETHYLPHOSPHORAMIDE $((CH_3)_2N)_3PO$

ANIMAL CARCINOGEN

Physical Properties:
Clear, colorless, mobile liquid, spicy odor; mp 6°C, bp 233°C.

Physiological Properties and Health Hazards:
An experimental carcinogen by inhalation route.

Waste Disposal:
Place in a separate labelled container for disposal by burning.

HYDRAZINE SOLUTIONS (hydrazine hydrate) NH_2NH_2

CAUSES BURNS

Hazard Rating:
Anhydrous Hydrazine: Health 3; Fire 3; Reactivity 2.

Physical Properties:
Colorless oily liquid; bp 113.5°C.

Chemical Properties:
Miscible with water.

Hazardous Reactions:
2,4-Dinitrochlorobenzene. Strongly exothermic reaction with 2,4-dinitrochlorobenzene.
Mercuric oxide. Dropwise addition to mercuric oxide may result in an explosion.
Sodium. Dropwise addition to a suspension of Na in ether and heating forms sodium hydrazide which explodes in air; reacts very exothermally with Na with the liberation of H_2 and NH_3.
Stannous chloride. Reacts to give stannous dihydrazine chloride which decomposes explosively when heated.

Physiological Properties and Health Hazards:
Avoid contact with eyes and skin. The liquid burns the eyes severely; the liquid burns the skin. If taken by mouth there is severe internal irritation and damage.

Spillage Disposal:
Wear face shield or goggles, and gloves. Mop up with plenty of water and run to waste, diluting greatly with running water.

Waste Disposal:
Add slowly to excess ice located in the hood behind a safety shield. Dilute with water to produce at least a 40% solution. The resulting mixture should then be neutralized and washed down the drain with excess water.

Storage:
Store in flammable solvent storage cabinet away from oxidants and acids.

Handling:
Wear safety glasses. For concentrated solutions, work behind a body shield.

HYDRIDES H^-

FLAMMABLE IN MOIST AIR. REACT VIOLENTLY WITH WATER

See ALUMINUM HYDRIDE
LITHIUM ALUMINUM HYDRIDE
POTASSIUM HYDRIDE
SODIUM HYDRIDE

HYDROCHLORIC ACID HCl

HARMFUL VAPOR. CAUSES BURNS.

Hazard Rating:
Health 3; Fire 0; Reactivity 0.

Physical Properties:
Colorless, fuming liquid with pungent smell, commonly available in reagent-grade of 38% HCl.

Chemical Properties:
Miscible with water.

Hazardous Reactions:
Potassium permanganate. A sharp explosion may be produced on adding concentrated acid to potassium permanganate.
Sodium. Aqueous HCl reacts explosively with sodium.
Sulfuric acid. Addition of concentrated HCl to concentrated H_2SO_4 dehydrates the HCl to release 250 times its volume of gas.

Physiological Properties and Health Hazards:
Vapor irritates respiratory system, eyes and skin. Liquid burns eyes and skin severely. Swallowing results in severe irritation and internal damage.
Avoid breathing vapor. Prevent contact with eyes and skin.

Spillage Disposal:
Instruct others to keep at a safe distance. Wear breathing apparatus and gloves. Spread sodium carbonate liberally over the spillage and mop up cautiously with water. Run to waste, diluting greatly with running water.

Waste Disposal:
Wear rubber gloves, self contained breathing apparatus, laboratory coat. Have body shield available.
Cautiously and slowly add to large volume of agitated solution of sodium carbonate and calcium hydroxide. Add the neutralized solution to excess running water.

Storage:
Store with mineral acids in a cool well ventilated cupboard separate from oxidizing materials and bases.

Handling:
Wear safety glasses and gloves. Use the fume hood.

Program References:
Challenges to Science – Life Science (Smallwood), Chapter 13, p. 252.
Physical Science – A Problem Solving Approach (Carter). Problem 17–3.
Physical Science: Interaction of Matter and Energy (Heath and McNaughton), 7.9, p. 149.
Life Science: A Problem–Solving Approach (Carter), Problem 14–3.
Biology BSCS Green version, 9.1.
Biology: Investigations in Biology (Benson *et al.*), 1, 6, 7, 8.
Biology: Investigations of Cells and Organisms (Abramoff and Thomson), 40, 41.
Alchem 10: C1, C3.
Alchem 20: I2, I3(D).
Alchem 30: L2, M1, M1(D), N1, N1(D), N2, N3(D), N4(D).
Keys to Chemistry: 1–2, 2–2, 2–4, 4–1, 4–2, 4–3, 4–4, 6–5, 7–4, 9–1, 9–4, 9–5, 11–1, 11–2.
Chemistry: Experiments and Principles, (Davis *et al.*), Ex. 5, 8, 12, 20, 21, 23, 26, 27, 30, 31, 32, 33, 36, 38, 39, 44.

HYDROCYANIC ACID HCN

EXTREMELY POISONOUS GAS AND LIQUID. POISONOUS BY SKIN ABSORPTION. HIGHLY FLAMMABLE.

Hazard Rating:
Health 4; Fire 4; Reactivity 2.

Physical Properties:
Colorless liquid or gas; characteristic odor of bitter almonds; bp 26°C.

Fire Hazard:
Flash point −18°C; explosive limits 6–41%; ignition temp. 538°C. Since the liquid is supplied in a cylinder, turning off the valve will reduce any fire involving it; if possible, cylinders should be removed quickly from an area in which a fire has developed. Breathing apparatus must be worn during these operations. Use dry chemical foam or carbon dioxide to extinguish.

Chemical Properties:
Very soluble in water, the solution being only weakly acidic. (Does not redden litmus.)

Hazardous Reactions:
Stable at or below room temperature in the presence of 0.1% acid; polymerizes explosively above 184°C or in the presence of alkali.
Heavy Metal Cyanides. Detonates explosively in presence of heavy metal cyanides.
Hydrochloric acid. Explosive reaction occurs when HCl is rapidly passed into alcoholic HCN; cold alcoholic HCN should be rapidly added to cold alcoholic HCl.
Ammonium chloride. Electrolysis of mixtures of NH_4Cl and HCN can form explosive nitrogen trichloride.

Physiological Properties and Health Hazards:
Inhalation of high concentrations leads to shortness of breath, paralysis, unconsciousness, convulsions and death by respiratory failure. With lethal concentrations, death is extremely rapid although breathing may continue for some time. With low concentrations the effects are likely to be headache, vertigo, nausea and vomiting. Chronic exposure over long periods may induce fatigue and weakness. The average fatal dose is 55 mg which can also be assimilated by skin contact with the liquid.
Antidote: Sodium nitrite and sodium thiosulfate.
Prevent inhalation of gas. Prevent contact with skin and eyes.

Spillage Disposal:
Wear long rubber gloves, self-contained breathing apparatus, laboratory apron or coat.
Evacuate the laboratory and isolate the area during contamination.
Follow waste disposal procedure.

Waste Disposal:
Breathing apparatus must be worn. For cylinder leak: if possible seal cylinder and return to supplier.
In the fume hood allow gas to leak into a container of sodium hydroxide solution while stopping leak (avoid possibility of suck back of alkaline material into liquid HCN.) Add excess calcium hypochlorite to the alkali cyanide. Discharge the cyanate into the drain with excess water.

Storage:
Do not store.

Handling:
Wear safety glasses and gloves. Use fume hood. Check for leakages with copper acetate-benzidine test papers.

HYDROFLUORIC ACID HF

GIVES OFF VERY POISONOUS VAPOR. CAUSES SEVERE BURNS.

Hazard Rating:
Health 4; Fire 0; Reactivity 0.

Physical Properties:
Colorless gas or liquid fumes in air; bp 19.5°C.

Chemical Properties:
Dissolves in water readily forming hydrofluoric acid.

Hazardous Reactions:
Mercury(II) oxide. Passing HF into rapidly stirred suspension of mercury(II) oxide may cause violent reaction.
Phosphorus pentoxide. Vigorous reaction with P_2O_5 below 20°C.
Oxides. Arsenic trioxide and calcium oxide incandesce in contact with the liquid.

Physiological Properties and Health Hazards:
Prevent inhalation of gas. Prevent contact with skin and eyes.
The gas irritates severely the eyes and respiratory system and may cause burns to the eyes. It irritates the skin and painful burns may develop after an interval. The liquid causes severe, painful burns on contact with all body tissues.

Spillage Disposal:
Wear face shield or goggles. Spread sodium carbonate liberally over the spillage and mop up cautiously with plenty of water; run to waste, diluting greatly with running water.

Waste Disposal:
Place in a labelled polythene container for disposal.

Storage:
Store in a well-ventilated area, separate from other chemicals.

Handling:
Wear neoprene gloves and safety glasses.

HYDROGEN PEROXIDE H_2O_2

CAUSES BURNS. CONTACT WITH COMBUSTIBLE MATERIAL MAY CAUSE FIRE

Hazard Rating:

35–52%: Health 2; Fire 0; Reactivity 1.
more than 52%: Health 2; Fire 0; Reactivity 3.

Physical Properties:

Colorless liquid; bitter taste. Distillable in high vacuum. May decompose violently if trace impurities are present. bp 152°C, mp −0.43°C.

Fire Hazard:

Strong oxidizer. Drying of concentrated product on clothing or other combustible material may cause fire. Avoid contamination from any source, including metals, dust, etc., as contamination may cause rapid decomposition, generation of large volumes of oxygen and high pressures.

Chemical Properties:

CAUTION! STRONG OXIDANT.
Marketed as an aqueous solution in concentrations of 3 – 90% by weight. Solutions of hydrogen peroxide gradually deteriorate and are usually stabilized by organic material. Agitation, contact with rough surfaces, metals, alkalies, and many other substances accelerate decomposition.
Store in original closed container. Be sure that the container vent is working properly. Do NOT add any other compound to the container. When empty, flush container thoroughly with clean water.

Hazardous Reactions:

Hazards associated with the use of H_2O_2 solutions have been published. These include:
a) Release of enough energy during catalytic decomposition of 65% peroxide to evaporate all water present and formed, and subsequent liability of ignition of combustible materials.
b) Most cellulosic materials contain enough catalyst to cause spontaneous ignition with 90% peroxide.
c) Contamination of concentrated peroxide causes possibility of explosion. Readily oxidizable materials, or alkaline substances containing heavy metals, may react violently.
d) Soluble fuels (acetone, ethanol, glycerol) will detonate on admixture with peroxide of over 30% concentration, the violence increasing with concentration.
e) Handling systems must exclude fittings of iron, brass, copper, Monel, and screwed joints caulked with red lead.
f) Concentrated peroxide may decompose violently in contact with iron, copper, chromium, and most other metals or their salts, and dust (which frequently contains rust). Absolute cleanliness, suitable equipment (PVC, butyl or Neoprene rubber) and personal protection are essential for safe handling. During concentration under vacuum of aqueous or of aqueous–alcoholic solutions of hydrogen peroxide, violent explosions occurred when the concentration was sufficiently high (probably above 90%). Detonation of hydrogen peroxide vapor has been studied experimentally.

Acetic acid. During the addition to acetic acid, the temperature must be controlled so that reaction proceeds steadily; otherwise reagent concentrations may increase to the point where reaction proceeds explosively.
Acetic anhydride. Reaction mixture with acetic anhydride must be kept acidic to prevent separation of the highly explosive diacetyl peroxide.
Acetone. Readily forms explosive dimeric and trimeric peroxides with acetone which have resulted in explosions during work–up of reactions run in acetone; acetone should not be used as solvent for peroxide oxidations.
Alcohols. Explosion of mixtures with alcohols can be initiated by shock or heat; furfuryl alcohol ignites on contact with 85% peroxide; addition of concentrated acid to alcohol–peroxide mixtures may result in explosion; adequate cooling must accompany initial additions of *tert*–butanol to H_2O_2:H_2SO_4 (1:2 by weight) mixtures to prevent explosive decomposition.
Carbon. Addition of charcoal to concentrated H_2O_2 results in violent decomposition; if a

trace of MnO_2 is present immediate ignition occurs.
Carboxylic Acids. The peroxyacids formed may be unstable and explosive.
Ketones. Hazardous reaction with acetone and HNO_3; other ketones yield shock- and heat-sensitive explosive peroxides.
Metals. Noble metals, especially when finely divided, cause explosive decomposition; Mn and Fe ignite on contact; cobalt, iron, lead, manganese, mercury, nickel and their oxides (especially rust) promote decomposition and must be excluded when using peroxides; potassium and sodium are oxidized violently.
Nitrogen-containing Bases. Ammonia in 99.6% H_2O_2 exploded violently; with hydrazine hydrate initial reaction may be slow, followed by sudden explosive reaction; 1,1-dimethylhydrazine ignites on contact with concentrated peroxide.
Organic Compounds. Mixtures of H_2O_2 and organic compounds may be dangerously explosive unless procedures are carefully controlled; destroying organic matter with 50% H_2O_2 and concentrated H_2SO_4 prior to analysis can be hazardous; during expoxidation of unsaturated organic compounds using 70% H_2O_2, reaction must proceed steadily to avoid build-up of reagents; during hydroxylation of vinyl acetate an explosion occurred when the reaction mixture was being vacuum distilled.
Phosphorus pentoxide. Violent reaction may be moderated using acetonitrile as diluent.
Stannous chloride. Strongly exothermic reaction is violent when peroxide solution is more than 3% by weight.

Physiological Properties and Health Hazards:

Avoid contact with eyes and skin.
Hydrogen peroxide, especially in higher concentrations, is irritant and caustic to the mucous membranes, eyes and skin. If swallowed, the sudden evolution of oxygen may cause injury by acute distension of the stomach and may cause nausea, vomiting and internal bleeding.

Spillage Disposal:

Wear face shield or goggles, and gloves. Mop up with plenty of water and run to waste, diluting greatly with running water.

Waste Disposal:

Wear rubber gloves, large face shield, laboratory coat. A body shield should be available. Dilute and wash down drain with excess of water.

Storage:

Store in original closed container away from combustible, organic and easily oxidized materials. Be sure that the container vent is working properly. Protect from sunlight.

Handling:

Wear safety glasses and gloves.

Program References:

Alchem 10: C1.
Chemistry: Experiments and Principles, (Davis *et al.*), Ex. 5.
Investigations in Biology, (Benson *et al.*), Investigation 15.

Use commercially supplied 3% solution of hydrogen peroxide in all above experiments.

HYDROGEN SULFIDE H_2S

EXTREMELY FLAMMABLE. TOXIC BY INHALATION.

Hazard Rating:
Health 3; Fire 4; Reactivity 0.

Physical Properties:
Colorless gas with an offensive odor characteristic of rotten eggs; bp −60.33°C.

Fire Hazard:
Explosive limits 4.3–45%; ignition temp 260°C. Since the gas is supplied in a cylinder, turning off the valve will reduce any fire involving it; if possible, cylinders should be removed quickly from an area in which a fire has developed.

Chemical Properties:
Soluble in water.

Hazardous Reactions:
Copper, Oxygen. A 1:2 mixture of hydrogen sulfide and oxygen ignites in the presence of copper powder.
Metal Oxides. Hydrogen sulfide may ignite in contact with barium dioxide, chromium trioxide, copper oxide, lead dioxide, manganese dioxide, nickel oxide, silver mono- and di-oxides, sodium peroxide and thallium trioxide. It may explode in the presence of air and mixtures of calcium or barium oxide with mercury or nickel oxide.
Metals. Copper powder reaches red heat in a mixture of air and hydrogen sulfide while finely divided tungsten glows in hydrogen sulfide. Sodium melts and then ignites in the presence of moist hydrogen sulfide.
Oxidants. Hydrogen sulfide ignites on contact with silver bromate, bromine pentafluoride, mercury(I) bromate, lead hypochlorite, copper chromate, fluorine, fuming nitric acid, solid sodium peroxide and dry or moist lead dioxide. Dichlorine oxide or chlorine trifluoride explode on contact with hydrogen sulfide. Heated chromium trioxide incandesces in a stream of hydrogen sulfide.
Oxygen. Mixtures of hydrogen sulfide and oxygen are explosive at temperatures between 280 and 360°C.
Rust. Hydrogen sulfide may ignite if passed through rusty iron pipes.
Soda-lime. There is an exothermic reaction between granular soda-lime and hydrogen sulfide which results in a violent explosion in the presence of oxygen. Barium hydroxide and sodium or potassium hydroxides behave similarly.

Physiological Properties and Health Hazards:
Gas at high concentration results in immediate unconsciousness and then cessation of breathing. At lowest concentrations gas irritates respiratory system and eyes and causes headache, dizziness and weakness.
Avoid inhaling gas.

Waste Disposal:
Wear rubber gloves, safety glasses. Work in hood or wear self-contained breathing apparatus, laboratory coat.
If a leak of H_2S, seal the cylinder and return to supplier. If the valve is leaking the gas can be bubbled through a $FeCl_3$ solution. Be sure to include a trap in the line to prevent the solution being sucked back into the cylinder. If this cannot be done, the cylinder should be placed in or adjacent to a fume hood and left to bleed off.
Surplus gas or leaking cylinder can be vented slowly into a water-fed scrubbing tower or column in a fume cupboard, or into a fume cupboard served by such a tower.

Storage:
Store cylinders upright and tightly secured away from nitric acid, strong oxidizing agents, or sources of ignition in a well ventilated area or fume hood.

Handling:
Wear safety glasses and gloves. Use the fume hood. Insidious poison.

Program References:

Alchem 30: N1(D); omit addition of HCl to NaHS to form H_2S.
Keys to Chemistry: 2–4; insignificant quantity of H_2S formed in reaction.
Ibid., 6–6; use thioacetamide only; do not prepare H_2S from FeS and HCl.

IODINE I_2

HARMFUL VAPOR. CAUSES BURNS.

Physical Properties:
Bluish-black crystalline scales or plates with a characteristic odor; mp 113.6°C.

Chemical Properties:
Almost insoluble in water.

Hazardous Reactions:
Acetaldehyde. Interaction may be violent.
Ammonia. Highly explosive addition compounds formed with ammonia solutions.
Ammonia and Potassium. In the presence of potassium, iodine in liquid ammonia may form the highly explosive nitrogen triiodide.
Ethanol and Phosphorus. Interaction of ethanol, phosphorus and iodine to form iodomethane is considered too dangerous for a school experiment.
Formamide. Bottles containing a modified Karl Fischer reagent when stored for several months may explode.
Halogens or Interhalogens. Bromine trifluoride incandesces in contact with I_2. Bromine pentafluoride ignites in contact with I_2 as do chlorine trifluoride and fluorine.
Metal Acetylides or Carbides. Many metal acetylides react very exothermally with I_2.
Metals. Antimony powder reacts violently; mixture of potassium and iodine explodes weakly on impact; potassium ignites in contact with molten I_2.
Metals and Water. Flash ignition occurs when mixtures of iodine with powdered aluminum, magnesium or zinc are moistened with a drop of water.
Non-Metals. Boron incandesces in I_2. Interaction of phosphorus and I_2 in carbon disulfide is rapid.
Silver azide. Silver azide is converted by ethereal I_2 to the highly explosive compound iodine azide.

Physiological Properties and Health Hazards:
Vapor irritates respiratory system and eyes. Solid irritates the eyes and burns the skin. Swallowing causes severe internal irritation and damage.
Avoid breathing vapor. Avoid contact with skin and eyes.

Spillage Disposal:
If the spillage is large and in a confined area, breathing apparatus should be worn. Large quantities are best disposed of by sweeping up with sand and placing in a labelled container. Small quantities can be dealt with by dissolving in sodium thiosulfate or sodium metabisulfate solution and running the resulting solution to waste, diluting greatly with running water. Iodine stains on flooring can be cleared by mopping with thiosulfate or metabisulfite solution.

Waste Disposal:
Wear rubber gloves, face shield, laboratory coat. In the fume hood, cautiously add to a large volume of concentrated solution of sodium thiosulfate. When reduction is complete add sodium carbonate or dilute hyrochloric acid to neutralize the solution. Wash into drain with large excess of water.

Storage:
Store in general chemical stores out of direct sunlight away from acetylene, ammonia, hydrogen.

Handling:
Wear safety glasses and gloves.

Program References:
Physical Science – A Problem-Solving Approach, (Carter), 14-1.
Physical Science: Interaction of Matter and Energy (Heath and McNaughton), 6.21, p. 131.
Biology: Investigations in Biology (Benson *et al.*), 11, 12, 16, 17, 25, 26.
Biology: Investigations of Cells and Organisms (Abramoff and Thomson), 15, 19, 21, 22, 24, 25.

Alchem 10: A2, C1.
Alchem 20: I3(D).
Keys to Chemistry, 7-1, 10-2.
Chemistry: Experiments and Principles, (Davis *et al.*), Ex. 28, 35, 38, 42, 43.

LEAD ACETATE $Pb(OCOCH_3)_2$

HARMFUL IF TAKEN INTERNALLY. DANGER OF CUMULATIVE EFFECTS.

Hazard Rating:
Health 3.

Physical Properties:
Colorless crystals or white granules or powder. Odor of acetic acid. mp 75°C.

Chemical Properties:
Soluble in water, alcohol, glycerol.

Hazardous Reactions:
Potassium bromate and Acetic acid. The double salt, lead acetate–lead bromate may be formed in the preparation of lead bromate from lead acetate and potassium bromate in acetic acid. It is explosive and very sensitive to friction.

Physiological Properties and Health Hazards:
Inhaling the dust or swallowing the solid may result in vomiting, diarrhea and collapse with severe internal damage. Prolonged exposure results in loss of appetite, pallor, anemia, constipation, colic and a blue line on the gums.
Avoid breathing dust.

Spillage Disposal:
Small quantities of soluble lead salts can be dissolved in water and the solution run to waste, diluting greatly with running water.

Waste Disposal:
Place solution in an evaporating dish in the fume hood. When all the liquid has evaporated, place the residue in a labelled sealed container for disposal.

Storage:
Store in general chemical stores.

Handling:
Wear safety glasses and gloves.

Program References:
Alchem 10: F1.

LEAD CHLORIDE $PbCl_2$

HARMFUL IF TAKEN INTERNALLY. DANGER OF CUMULATIVE EFFECTS.

Physical Properties:
White, crystalline powder, mp 501°C.

Chemical Properties:
Soluble in 93 parts cold water, 30 parts boiling water.

Hazardous Reactions:
Calcium. Explosive interaction on warming.

Physiological Properties and Health Hazards:
Inhaling the dust or swallowing the solid may result in vomiting, diarrhea and collapse with severe internal damage. Prolonged exposure results in loss of appetite, pallor, anemia, constipation, colic and a blue line on the gums.
Avoid breathing dust.

Spillage Disposal:
Small quantities of soluble lead salts can be dissolved in water and the solution run to waste, diluting greatly with running water.

Waste Disposal:
Place solution in an evaporating dish in the fume hood. When all the liquid has evaporated, place the residue in a labelled sealed container for disposal.

Storage:
Store in general chemical stores.

Handling:
Wear safety glasses and gloves.

Program References:
Chemistry: Experiments and Principles, (Davis *et al.*), Ex. 21, 38.

LEAD NITRATE $Pb(NO_3)_2$

HARMFUL IF TAKEN INTERNALLY. DANGER OF CUMULATIVE EFFECTS.

Hazard Rating:
Health 1; Fire 0, Reactivity 0.

Physical Properties:
White or colorless translucent crystals.

Fire Hazard:
Ignites or explodes on contact with organic or easily combustible materials.

Chemical Properties:
One gram dissolves in 2 mL cold, 0.75 mL boiling water.

Hazardous Reactions:
Potassium acetate. A heated mixture may explode violently.

Physiological Properties and Health Hazards:
Inhaling the dust or swallowing the solid may result in vomiting, diarrhea and collapse, with severe internal damage. Prolonged exposure results in loss of appetite, pallor, anemia, constipation, colic and a blue line on the gums.
Avoid breathing dust.

Spillage Disposal:
Small quantities of soluble lead salts can be dissolved in water and the solution run to waste, diluting greatly with running water.

Waste Disposal:
Place solution in an evaporating dish in the fume hood. When all the liquid has evaporated, place the residue in a labelled sealed container for disposal.

Storage:
Store in general chemical stores.

Handling:
Wear safety glasses and gloves.

Program References:
Physical Science: Interaction of Matter and Energy (Heath and McNaughton), Ch. 11.2, p. 221.
Alchem 10: C3, E1(D).
Alchem 20: I2, J3.
Alchem 30: M1.
Keys to Chemistry: 1–2, 3–3, 6–5, 8–3, 8–4, 10–3, 11–2.
Chemistry: Experiments and Principles, (Davis *et al.*), Ex. 17, 21, 23, 35, 38.

LEAD SALTS Pb

HARMFUL IF TAKEN INTERNALLY. DANGER OF CUMULATIVE EFFECTS.

Hazard Rating:
Lead Carbonate: Health 3.
Lead Thiocyanate: Health 1; Fire 1, Reactivity 1.

Physical Properties:
White or colored crystals or powders.

Hazardous Reactions:
See also individual lead compounds.

LEAD AZIDE $Pb(N_3)_2$
Used widely as a detonator. A vacuum desiccated sample exploded violently when touched with a metal spatula.
Copper or Zinc. Prolonged contact of the azide with copper, zinc or their alloys forms traces of extremely explosive copper or zinc azides.

LEAD CHLORATE $Pb(ClO_3)_2$
Thermal decomposition may be explosive.

LEAD CHROMATE $PbCrO_4$
The mixture with sulfur is pyrophoric.

LEAD(II) OXIDE PbO
Metals. Mixtures with aluminum and titanium give violent reaction on heating; mixture with zirconium explodes on heating; mixture with finely divided sodium ignites.
Non-Metals. Mixture with boron incandesces on heating; mixture with silicon gives vigorous reaction on heating.

LEAD(IV) OXIDE PbO_2
Hydrogen sulfide. Ignition occurs on contact of the gas with the metal oxide.
Metals. Potassium reacts explosively and magnesium violently.
Nitroalkanes. Ignition temperature of nitromethane, nitroethane and 1-nitropropane and sensitivity of nitromethane to detonation lowered by contact with lead oxide.
Nitrogen Compounds. Hydroxylamine ignites and phenylhydrazine reacts vigorously on contact with the oxide.
Non-Metals. Mixtures of boron or yellow phosphorus with the oxide explode violently on grinding; mixtures of sulfur or red phosphorus with the oxide ignite on grinding.

LEAD PERCHLORATE $Pb(ClO_4)_2$
Saturated solution in methanol exploded violently when disturbed, possibly due to the formation of methyl perchlorate.

LEAD PICRATE $Pb(C_6H_2N_3O_7)_2$
Qualitative inorganic analysis of compounds containing lead and salicylate radicals can lead to the formation of explosive lead picrate.

LEAD THIOCYANATE $Pb(SCN)_2$
The salt is explosive.

Physiological Properties and Health Hazards:
Inhaling the dust or swallowing the solid may result in vomiting, diarrhea and collapse, with severe internal damage. Prolonged exposure results in loss of appetite, pallor, anemia, constipation, colic and a blue line on the gums.
Avoid breathing dust.

Spillage Disposal:

Small quantities of soluble lead salts can be dissolved in water and the solution run to waste, diluting greatly with running water. Insoluble compounds can be mixed with an excess of sand and disposed of as normal refuse.

Waste Disposal:

Place solution in an evaporating dish in the fume hood. When all the liquid has evaporated, place the residue in a labelled sealed container for disposal.

Storage:

Store in general chemical stores.

Handling:

Wear safety glasses and gloves.

Program References:

Lead: Alchem 10: A2.
Alchem 30: M1.
Chemistry: Experiments and Principles (Davis *et al.*), Ex. 35, 37.
Lead chromate: Chemistry: Experiments and Principles, (Davis *et al.*), Ex. 21.
Lead hydroxide: Chemistry: Experiments and Principles, (Davis *et al.*), Ex. 21.
Lead iodide: Alchem 10: C3.
Alchem 20: I2.
Keys to Chemistry: 8–4.
Chemistry: Experiments and Principles, (Davis *et al.*), Ex. 17.
Lead oxide: Chemistry: Experiments and Principles, (Davis *et al.*), Ex. 23.

LEAD SULFATE $PbSO_4$

HARMFUL IF TAKEN INTERNALLY. DANGER OF CUMULATIVE EFFECTS.

Physical Properties:
White, heavy crystalline powder, mp 1170°C.

Chemical Properties:
Soluble in 2225 parts water.

Hazardous Reactions:
Potassium. Violent or explosive interaction.

Physiological Properties and Health Hazards:
Inhaling the dust or swallowing the solid may result in vomiting, diarrhea anad collapse, with severe internal damage. Prolonged exposure results in loss of appetite, pallor, anemia, constipation, colic and a blue line on the gums.
Avoid breathing dust.

Spillage Disposal:
Small quantities of soluble lead salts can be dissolved in water and the solution run to waste, diluting greatly with running water. Insoluble compounds can be mixed with an excess of sand and disposed of as normal refuse.

Waste Disposal:
Place solution in an evaporating dish in the fume hood. When all the liquid has evaporated, place the residue in a labelled sealed container for disposal.

Storage:
Store in general chemical stores.

Handling:
Wear safety glasses and gloves.

LITHIUM ALUMINUM HYDRIDE $LiAlH_4$

CONTACT WITH WATER LIBERATES HIGHLY FLAMMABLE GASES IRRITATING TO SKIN AND EYES

Hazard Rating:
Health 3; Fire 1; Reactivity 2.

Physical Properties:
Microcrystalline white powder when pure, gray when aluminum impurity present; decomposes above 125°C.

Fire Hazard:
This arises usually by contact with small quantities of water or by heating. Such a fire is best extinguished by smothering with sand and disposing in the manner given below. Do not use water.

Chemical Properties:
Keep container tightly closed. Strong reductant; reacts rapidly with water with evolution of hydrogen. Reacts rapidly with alcohols.

Hazardous Reactions:
May ignite on grinding in a dry mortar; ignites in moist air or oxygen; spilled ether mixture may ignite after ether has evaporated.
Alkyl Benzoates. Reduction of benzaldehyde with 4-fold excess of $LiAlH_4$ may be dangerous.
Bis(2-methoxyethyl)ether. Violent explosion occurred when the ether was distilled from $LiAlH_4$ at 200°C.
Boron trifluoride diethyl etherate. Addition of lumps of $LiAlH_4$ to etherate containing peroxide caused explosion.
1,2-Dimethoxyethane. Explosion resulted during addition of 1,2-dimethoxyethane to $LiAlH_4$; caution is required during distillation of solvent from $LiAlH_4$.
Dioxane. Explosion occurred during distillation of this solvent from $LiAlH_4$; nitrogen atmosphere is necessary for this reaction.
Ethyl acetate. Explosion occurred when ethyl acetate was used to destroy excess $LiAlH_4$; either a solution of ethyl acetate in an inert solvent or a moist unreactive solvent should be used.
Fluoroamides. Reduction with $LiAlH_4$ is hazardous at all stages.
Pyridine. Reaction is highly exothermic.
Tetrahydrofuran. Addition of $LiAlH_4$ to dried tetrahydrofuran which had been stored over calcium hydride caused explosion.
Water. Vigorous reaction with ignition of liberated H_2.

Physiological Properties and Health Hazards:
Reaction with moisture forms corrosive lithium hydroxide which irritates the skin and eyes.
Avoid contact with skin, eyes and clothing

Spillage Disposal:
Instruct others to keep at a safe distance. Wear face shield or goggles, and gloves. Cover with dry sodium carbonate, shovel into dry bucket, transport to fume hood and add, a little at a time, to a large excess of dry propan-2-ol. Leave to stand for 24 hours and run to waste diluting greatly with running water.

Waste Disposal:
For reaction mixtures: In the fume hood, behind a shield, cautiously and slowly carry out the following procedure. The stirred reaction mixture from *n* grams of $LiAlH_4$ is treated by successive dropwise addition of *n* mL of H_2O, *n* mL of 15% NaOH solution and 3*n* mL of H_2O. This produces a dry granular precipitate. Flush down drain with excess water.
For packaged lots: Place in separate labelled container for disposal.

Storage:
Protect container from physical damage. Store in a cool, *dry* place with other reducing

agents and isolated from other chemicals.

Handling:

Wear safety glasses and gloves. Avoid water. Have body shield and dry sand (to extinguish fires) available.

MALEIC ANHYDRIDE $C_4H_2O_3$

IRRITATING TO SKIN, EYES AND RESPIRATORY SYSTEM

Hazard Rating:
Health 3; Fire 1; Reactivity 1.

Physical Properties:
White crystalline powder or lumps; mp 52.8°C.

Chemical Properties:
Reacts with water forming maleic acid.

Hazardous Reactions:
Cations or Bases. In the presence of sodium ions or pyridine, maleic anhydride decomposes exothermally above 150°C with evolution of CO_2. Also effective as catalysts in the decomposition are other alkali or alkaline earth metal or ammonium ions, dimethylamine, triethylamine and quinoline.

Physiological Properties and Health Hazards:
Dust and vapor irritate the eyes, skin and respiratory system. Swallowing causes irritation and internal damage. Prolonged exposure to skin contact may cause burns.
Avoid breathing dust. Avoid contact with skin and eyes.

Spillage Disposal:
Eliminate all sources of ignition. Cover contaminated surfaces with sodium carbonate or sodium bicarbonate. Mix and add water if necessary. Scoop up slurry and wash neutral waste down drain with excess water. Wash site with sodium carbonate solution.

Waste Disposal:
Place in a separate, labelled container for disposal by burning.

Storage:
Store in general stores away from moisture, heat and light.

Handling:
Wear safety glasses and gloves. Use fume hood.

MERCURY Hg

GIVES OFF VERY POISONOUS VAPOR. DANGER OF CUMULATIVE EFFECTS

Hazard Rating:
Health 3.

Physical Properties:
Heavy silvery liquid; insoluble in water.

Hazardous Reactions:
Ammonia. Prolonged contact may yield explosive solid; use of mercury manometers with NH_3 should be avoided.
Bromine. Reacts violently with dry bromine.
Metals. Ease with which Hg forms amalgams with many laboratory and electrical contact metals can cause severe corrosion problems.
Peroxyformic acid. Readily causes explosions when added to 90% acid.

Physiological Properties and Health Hazards:
Avoid breathing vapor. Avoid contact with eyes and skin.
High concentrations of vapor may cause metallic taste, nausea, abdominal pain, vomiting, diarrhea, and headache. Chronic effects: Continued exposure to small concentrations of vapor may result in severe nervous disturbance, including tremor of the hands, insomnia, loss of memory, irritability and depression; other possible effects are loosening of teeth and excessive salivation. Continued skin contact with mercury may cause dermatitis and the above effects may be caused by absorption through the skin or following ingestion. Kidney damage may ensue.

Spillage Disposal:
Because of the high toxicity of mercury vapor, it is important to clean up mercury as thoroughly as possible, especially in confined areas. A small aspirator with a capillary tube and connected to a pump can be used for sucking up droplets. For fine drops of mercury in inaccessible sites, treat with calcium polysulfide and excess sulfur.

Waste Disposal:
CAUTION: The toxicity of mercury is such that the element and its compounds should not be allowed to contaminate air or water.
Wear rubber gloves, self-contained breathing apparatus, laboratory coat.
Metal: Collect all droplets and pools at once by means of suction pump and aspirator bottle with a long capillary tube. Cover fine droplets in nonaccessible cracks with calcium polysulfide and excess sulfur. Combine all contaminated mercury in a tightly stoppered bottle. Return to manufacturer for recycling.

Storage:
Store small quantities in a tightly closed polyethylene bottle away from nitrates and chlorates. Cover the surface with water to protect against evaporation.

Handling:
Wear safety glasses and gloves.

Program References:
Physical Science Investigations (Carter): Experiment 5-12, p. 142; for measurement of expansion and contraction of air, substitute colored water to measure gas volume; omit preparation of mercury barometer and Boyle's experiment.
Ibid., 7-9, p. 215; use colored water to replace drop of mercury.
Alchem 10: A2; omit sample of mercury.
Ibid., D2; omit.
Chemistry: Experiments and Principles, (Davis *et al.*), Ex. 12; omit use of barometer.

If possible, substitute alcohol thermometer or thermistor for mercury thermometer; otherwise, note treatment for mercury spills.

MERCURY COMPOUNDS Hg_2^{2+},Hg^{2+}

POISONOUS DUST. SERIOUS RISK OF POISONING BY INHALATION, SWALLOWING OR SKIN CONTACT. DANGER OF CUMULATIVE EFFECTS. CAUSE IRRITATION OF SKIN AND EYES

Mercury compounds vary widely in appearance, solubility in water and toxicity. Mercuric compounds are generally more toxic than mercurous compounds. Some organic mercurial compounds are liquids with an extremely poisonous vapor, others are solids, the toxicity of which is not known with certainty. Thus phenylmercuric acetate appears relatively non-toxic but the alkyl mercurials are highly poisonous. Their toxicity by skin absorption is uncertain, but some, for example, ethyl mercury phosphate and mercury fulminate, can cause dermatitis. The effects vary greatly according to the nature of the organic mercurial. Some compounds cause kidney damage while others can cause irreversible damage to the central nervous system.

Hazard Rating:

Health 3; Fire 0; Reactivity 0.

Hazardous Reactions:

MERCURIC AZIDE $Hg(N_3)_2$
Explosively unstable.

MERCURIC CHLORITE $Hg(ClO_2)_2$
Explosive salt.

MERCURIC NITRATE $Hg(NO_3)_2$
Acetylene. Contact with acetylene gives explosive mercury(II) acetylide.
Ethanol. In ethanol, mercury(II) fulminate may be formed.
Petroleum hydrocarbons. Risk of violent reaction with petroleum hydrocarbons.
Phosphine. Aqueous solution reacts with phosphine to give explosive complex.

MERCURIC OXIDE HgO
Hydrazine. Explosive reaction with hydrazine hydrate.

MERCURIC SULFATE $HgSO_4$
Hydrogen chloride. Absorption of gaseous HCl becomes violent at 125°C.

MERCUROUS AZIDE $Hg_2(N_3)_2$
Explodes in air on heating at 210°C.

MERCUROUS OXIDE Hg_2O
Hydrogen peroxide. Reacts explosively with hydrogen peroxide.

MERCURY HALIDES HgX_2, Hg_2X_2
Potassium. Mixtures of mercuric bromide, mercuric chloride, mercuric fluoride, mercuric iodide or mercurous chloride with potassium explode on impact.

Physiological Properties and Health Hazards:

Inhalation of dust may cause nausea, abdominal pain, vomiting, diarrhea and headache. Skin absorption may give rise to similar effects and the eyes may be damaged by direct contact with some salts. Abdominal pain, nausea, vomiting, diarrhea and shock follow ingestion of the soluble mercuric salts. Kidney damage may ensue.
Chronic effects. The intake of small amounts of mercury compounds by inhalation, skin absorption, or ingestion over a long period may cause nervous disturbance, including tremor of the hands, insomnia, loss of memory, irritability and depression; other possible effects are loosening of the teeth and excessive salivation.
Avoid breathing dusts. Avoid contact with skin and eyes.

Spillage Disposal:

See waste disposal.

Waste Disposal:

CAUTION: The toxicity of mercury is such that the element and its compounds should not be allowed to contaminate air or water.
Wear rubber gloves, self-contained breathing apparatus, laboratory coat.
Dissolve all water-soluble contaminated compounds. Convert other contaminated compounds to the soluble nitrates. Adjust the acidity and precipitate as mercuric sulfide. Wash and dry the precipitate. Ship to the supplier.

Storage:
Store in general chemical stores.

Handling:
Wear safety glasses and gloves.

Program References:
Mercuric chloride: Keys to Chemistry: 6-6, 11-2; omit Hg^{2+} as cation.
Mercuric chromate: Chemistry: Experiments and Principles, (Davis *et al.*), Ex. 21; omit Hg^{2+} as cation.
Mercuric nitrate: Keys to Chemistry: 11-2; omit Hg^{2+} as cation.
Chemistry: Experiments and Principles, (Davis *et al.*), Ex. 21; omit Hg^{2+} as cation.
Mercuric Oxide: Physical Science Investigations (Carter), 7-6, p. 210; substitute PbO_2.
Physical Science: Interaction of Matter and Energy (Heath and McNaughton), Exp. 7.11; omit.
Alchem 10: D2; omit.
Keys to Chemistry 8-3; substitute PbO_2.
Mercuric sulfide: Keys to Chemistry: 6-6; Hg^{2+} omitted as cation, no HgS formed.
Mercurous chloride: Chemistry: Experiments and Principles, (Davis *et al.*), Ex. 21; omit Hg_2^{2+} as cation.
Mercurous nitrate: Chemistry, Experiments and Principles, (Davis *et al.*), Ex. 21; omit Hg_2^{2+} as cation.

METHANOL (methyl alcohol) CH_3OH

HIGHLY FLAMMABLE. SERIOUS RISK OF POISONING BY INHALATION OR SWALLOWING.

Hazard Rating:
Health 1; Fire 3; Reactivity 0.

Physical Properties:
Colorless, volatile liquid, bp 65°C.

Fire Hazard:
Flash point 10°C; explosive limits 7.3 – 36.5%; ignition temp 464°C. Extinguish fire with water spray, dry powder, carbon dioxide or vaporizing liquid.

Chemical Properties:
Miscible with water.

Hazardous Reactions:
Acetyl bromide. Interaction is violent, HBr being evolved.
Air. Methanol–air mixtures at 1.81 bar and 120°C may explode with or without the addition of oxygen and water.
Dichloromethane. Dichloromethane may become flammable in the presence of small amounts of methanol.
Metals. Reaction with Mg is vigorous and often subject to a lengthy induction period. Mixtures with powdered Mg or Al are capable of powerful detonation. Reaction with K may lead to an explosion.
Oxidants. Methanol may react violently with oxidizing agents.
Potassium tert-butoxide. Reaction of liquid with the solid butoxide causes ignition after 2 min.
Water. Methanol:water, 40:60 at 30°C and methanol:water, 30:70 mixtures can be ignited by a static discharge.

Physiological Properties and Health Hazards:
Vapor irritates mucous membrane and may cause headache, nausea and vomiting. Breathing high concentration of vapor may cause giddiness, stupor and stomach upset. The vapor and the liquid can cause severe eye damage, sometimes several hours after exposure. Swallowing the liquid or prolonged exposure to low vapor concentrations may cause temporary or permanent blindness and damages the central nervous system, the kidneys, liver and heart eventually resulting in death.
Avoid breathing vapor. Avoid contact with skin and eyes.

Spillage Disposal:
Shut off all possible sources of ignition. Instruct others to keep at a safe distance. Wear breathing apparatus and gloves. Mop up with plenty of water and run to waste, diluting greatly with running water. Ventilate area well to evaporate remaining liquid and dispel vapor.

Waste Disposal:
Place waste in non–halogenated solvent disposal container for disposal by burning.

Storage:
Store in general flammable solvent storage cabinet away from sources of ignition.

Handling:
Wear safety glasses. When using large quantities work in the fume hood.

Program References:
Alchem 10: B2, D1.
Alchem 20: H3, I3.
Alchem 30: N1(D).
Keys to Chemistry: 9–6.
Chemistry: Experiments and Principles, (Davis *et al.*), Ex. 25, 39, 40.

4,4'-METHYLENE-BIS-(2-CHLOROANILINE) $(H_2NC_6H_3Cl)_2CH_2$
(3,3'-dichloro-4,4'-diaminodiphenyl methane)

ANIMAL CARCINOGEN

Waste Disposal:
Place in a separate, labelled container for disposal by burning.

METHYLHYDRAZINE CH_3NHNH_2

SUSPECTED ANIMAL CARCINOGEN

Physical Properties:
Clear liquid, amine odor; bp 87.5°C.

Fire Hazard:
Flammable. Flash point −8°C. Ignition temp 196°C; Flammability limits 2.5–92%.

Chemical Properties:
Miscible with water; mild base; strong reducing agent.

Hazardous Reactions:
Oxidants. Ignites on contact with hydrogen peroxide or nitrogen dioxide among other oxidants.

Spillage Disposal:
Wear rubber gloves, self-contained breathing apparatus. Impervious clothing recommended. Body shield should be available.
Eliminate all sources of ignition and flammables.
On skin or clothing. Wash skin immediately. Remove contaminated clothing at once.
Large spills. Collect the liquid with an aspirator such as used for recovering spilled mercury. Empty into a large beaker and neutralize with dilute sulfuric acid. Wash to drain with excess water. Wash site with soap and water.

Waste Disposal:
Place in a separate labelled container for disposal by burning.

METHYL IODIDE (iodomethane) CH_3I

CANCER SUSPECT AGENT. TOXIC IN CONTACT WITH SKIN. GIVES OFF POISONOUS VAPOR. CAUSES BURNS

Physical Properties:
Colorless liquid, turns brown on exposure to light, bp 42.5°C.

Chemical Properties:
Sparingly soluble in water. Miscible with alcohol, ether. Protect from light.

Hazardous Reactions:
Sodium. Vigorous reaction with Na dispensed in either toluene or benzene.

Physiological Properties and Health Hazards:
Inhalation of vapor may cause dizziness, drowsiness, mental confusion, muscular twitching and delirium. The vapor and liquid irritate the eyes and distort the vision. The liquid irritates the skin and may cause blistering. The liquid must be assumed to be irritant and poisonous if taken by mouth.
Avoid breathing vapor. Prevent contact with skin and eyes.

Spillage Disposal:
Instruct others to keep at a safe distance. Wear breathing apparatus and gloves. Absorb on sand, shovel into bucket and transport to fume hood for atmospheric evaporation. Site of spillage should be washed thoroughly with water and soap.

Waste Disposal:
Place in a separate labelled container for disposal by burning.

MILLON'S REAGENT $Hg(NO_3)_2/HNO_3$

POISONOUS

Hazard Rating:
Health 3.

Physical Properties:
A solution of mercuric nitrate in concentrated nitric acid.

Chemical Properties:
Proteins containing tyrosine give a positive test with Millon's reagent.

Hazardous Reactions:
Mercuric nitrate is toxic. Concentrated nitric acid is corrosive. Boiling a protein with Millon's reagent is extremely hazardous.

Spillage Disposal:
See waste disposal.

Waste Disposal:
CAUTION: The toxicity of mercury is such that the element and its compounds should not be allowed to contaminate air or water.
Wear rubber gloves, self-contained breathing apparatus, laboratory coat.
Dissolve all water-soluble contaminated compounds. Convert other contaminated compounds to the soluble nitrates. Adjust the acidity and precipitate as mercuric sulfide. Wash and dry the precipitate. Ship to the supplier.

Storage:
Store in poison cupboard.

Handling:
Wear safety glasses and gloves.

Program References:
Investigations of Cells and Organisms (Abramoff and Thomson). 16. Substitute Hopkins-Cole reaction: Glyoxylic acid in concentrated sulfuric acid gives purple color in presence of tryptophan.

MORPHOLINE C_4H_9NO

FLAMMABLE. IRRITATING TO SKIN, EYES AND RESPIRATORY SYSTEM.

Hazard Rating:
Health 2; Fire 3; Reactivity 0.

Physical Properties:
Colorless, mobile, hygroscopic liquid with amine-like odor; bp 127°C.

Fire Hazard:
Flash point 38°C (open cup); ignition temp 310°C. Extinguish fire with dry powder, carbon dioxide or vaporizing liquid.

Chemical Properties:
Miscible with water.

Hazardous Reactions:
Cellulose nitrate. High surface area cellulose nitrate ignites spontaneously on contact with morpholine.
Nitromethane. Addition of morpholine makes nitromethane susceptible to initiation by a detonator.

Physiological Properties and Health Hazards:
Vapor irritates eyes and respiratory system. Liquid irritates eyes and skin. Swallowing causes internal irritation and kidney and liver damage.
Avoid breathing vapor. Avoid contact with skin, eyes and clothing.

Spillage Disposal:
Wear butyl rubber gloves, plastic laboratory coat, self-contained breathing apparatus.
Spills on Skin and Clothing. Wash skin with strong soap solution immediately. Rinse thoroughly. Contaminated clothing should be removed, dried, and washed with strong soap solution, or destroyed. It may be necessary to destroy shoes by burning.
Small Spills. Absorb on paper towels. Place in an iron pan and allow evaporation in the fume hood. Add crumpled paper and burn. Wash site with strong soap and solution.
Large Spills. Cover large spills with sand and sodium carbonate mixture (90-10). Mix and shovel into a cardboard box and label. Dispose by burning.

Waste Disposal:
Place in a non-halogenated solvent disposal container for disposal by burning.

Storage:
Store in a cool, dark area away from mineral acids.

Handling:
Wear safety glasses.

1-NAPHTHYLAMINE AND SALTS $C_{10}H_7NH_2$

HUMAN CARCINOGEN. POISONOUS DUST. TOXIC IN CONTACT WITH SKIN. DANGER OF CUMULATIVE EFFECTS.

Physical Properties:

Colorless crystals when pure, darkening on exposure to light and air; unpleasant odor; mp 50°C (base).

Chemical Properties:

1-Naphthylamine is soluble in 590 parts water; the hydrochloride is soluble in 27 parts water.

Physiological Properties and Health Hazards:

Salts or solutions irritate eyes. Prolonged exposure to dust or skin absorption may cause tumors of the bladder.

Avoid inhalation of dust. Avoid contact with skin, eyes or clothing.

Spillage Disposal:

Wear rubber gloves, plastic laboratory coat, self-contained breathing apparatus.

On skin and clothing. Wash skin with strong soap solution immediately. Rinse thoroughly. Contaminated clothing should be removed, dried, and washed with strong soap solution, or destroyed. It may be necessary to destroy shoes by burning.

Small spills. Brush solids onto paper. Add crumpled paper and burn. Wash site with strong soap solution.

Large spills. Cover large spills with sand and sodium carbonate mixture (90-10). Mix and shovel into a cardboard box. Follow waste disposal.

Waste Disposal:

Place in a separate labelled container for disposal by burning.

2-NAPHTHYLAMINE AND SALTS

$C_{10}H_7NH_2$

HUMAN CARCINOGEN

Physical Properties:

White to reddish crystals; mp 111–113°C.

Chemical Properties:

Soluble in hot water.

Physiological Properties and Health Hazards:

A human carcinogen by oral and subcutaneous routes. Inhalation or absorption through the skin of the dust has been recognized as a cause of bladder tumors.

Spillage Disposal:

Wear rubber gloves, plastic laboratory coat, self-contained breathing apparatus.

On skin and clothing. Wash skin with strong soap solution immediately. Rinse thoroughly. Contaminated clothing should be removed, dried, and washed with strong soap solution, or destroyed. It may be necessary to destroy shoes by burning.

Small spills. Brush solids onto paper. Add crumpled paper and burn. Wash site with strong soap solution.

Large spills. Cover large spills with sand and sodium carabonate mixture (90–10). Mix and shovel into a cardboard box. Follow waste disposal.

Waste Disposal:

Place in a separate labelled container for disposal by burning.

NITRIC ACID HNO_3

CONTACT WITH COMBUSTIBLE MATERIALS MAY CAUSE FIRES. CAUSES SEVERE BURNS.

Hazard Rating:
Health 3; Fire 0; Reactivity 0.

Physical Properties:
Colorless or pale yellow fuming liquid; characteristic choking odor.

Chemical Properties:
Miscible with water.

Hazardous Reactions:
The oxidizing power (and hazard potential) of nitric acid increases progressively with increase in strength from the concentrated acid (70% wt HNO_3) through fuming acids (above 85% wt) to the anhydrous 100% acid. The presence of dissolved oxides of nitrogen in the red fuming grades of acid further enhances the potency of the oxidant.

Winchesters of fuming nitric acid may develop pressure on storage, owing to attack on the plastic screw cap if the inert protective cap liner fails. Regular pressure release is recommended by one laboratory supplier.

Acetic anhydride. Mixtures containing more than 50% fuming HNO_3 are detonable; mixtures containing less than 50% HNO_3 react uncontrollably with small quantities of water.

Acetone. Ignites on contact with fuming HNO_3.

Acetone and Acetic acid. Mixture containing equal parts of the components will explode if kept in a closed container.

Acetone and Sulfuric acid. Mixture may explode if confined in narrow-mouthed vessel.

Acetonitrile. Mixture forms high explosive.

Alcohols. Mixtures of nitric acid and alcohols are quite unstable.

Alcohols and Potassium permanganate. Addition of alcohols to fuming HNO_3 containing potassium permanganate results in immediate ignition.

Aliphatic Amines. Mixtures of amines with fuming HNO_3 may ignite.

Ammonia. A jet of ammonia will ignite in HNO_3 vapor.

Aromatic Amines. Many aromatic amines ignite on contact with fuming HNO_3.

Cellulose. May be converted to the highly flammable nitrate ester on contact with HNO_3 vapor as well as with liquid.

4-Chloro-2-nitroaniline. Primary aromatic amines should be protected by acetylation before nitration to avoid the possibility of accidental diazotization.

Crotonaldehyde. Ignites in concentrated HNO_3.

1,2-Dichloroethane. Mixtures are easily detonated by heat, impact or friction.

Dichloromethane. Solution is detonable.

Dichromates. Dichromates, particularly ammonium dichromate promote ignition of mixtures of fuming HNO_3 with cyclohexanol, *m*- or *o*-cresol and furfural.

Diethyl ether, Dimethyl ether. Addition of ether to 50% aqueous HNO_3 can cause an explosion. A mixture of the ether, HNO_3 and H_2SO_4 explodes violently.

1,1-Dimethylhydrazine. Ignites on contact with HNO_3.

Dimethyl sulfide and Dioxane. Mixture explodes after a delay, even at liquid nitrogen temperature.

Fat and Sulfuric acid. Mixtures of adipose tissue and fuming nitric and sulfuric acids sealed in bombs, exploded.

Hydrazine and Derivatives. Mixtures with concentrated HNO_3 ignite on contact.

Hydrocarbons. Dienes and acetylene derivatives ignite in concentrated HNO_3. Cyclopentadiene reacts explosively with fuming HNO_3. Benzene solutions containing 84% acid are very sensitive to detonation. Nitration of toluene must be carefully controlled or an explosion may occur. During the nitration of mesitylene in acetic acid-anhydride solution the temperature must be kept below 20°C.

Hydrogen iodide, Hydrogen selenide, Hydrogen sulfide. Ignition occurs on contact with fuming HNO_3.

Hydrogen peroxide and Ketones. Explosive ketone peroxides may be produced.

Ion Exchange Resins. Interaction with anion exchange resins and HNo_3 may cause explosions.

Iron(III) oxide. Finely divided oxide incandesces in HNO_3.

Metals. Bismuth glows red hot in contact with fuming HNO_3. Germanium reacts violently; lithium ignites. Manganese powder incandesces and sodium ignites. Titanium alloys form an explosive deposit; uranium powder reacts vigorously. Molten zinc incandesces; magnesium burns brilliantly.
4-Methylcyclohexanone. Mixture with concentrated HNO_3 may explode at about 75°C.
Nitroaromatics. Mixtures of HNO_3 with mono- and di-nitrobenzenes and di- and tri-nitrotoluenes possess high explosive properties.
Nitromethane. Mixtures with HNO_3 are extremely explosive.
Non-Metal Hydrides. Arsine, phosphine and tetraborane are oxidized explosively by fuming HNO_3 and stibine by concentrated HNO_3. Phosphine, hydrogen sulfide and hydrogen selenide ignite in contact with fuming acid. Hydrogen telluride ignites with cold concentrated acid.
Non-Metals. Boron reacts violently with concentrated HNO_3. Phosphorus vapor may ignite. Silicon, arsenic and finely divided carbon react violently.
Organic Matter. Organic matter may explode with concentrated HNO_3.
Phosphorus Halides. Phosphorus trichloride explodes with HNO_3.
Phthalic anhydride and Sulfuric acid. Excess nitrating mixture (HNO_3 + H_2SO_4) caused delayed vigorous reaction with phthalic anhydride.
Polyalkenes. Fuming HNO_3 will attack polyethylene or polypropylene but not polytetrafluoroethylene.
Sulfur dioxide. Presence of dinitrogen tetroxide appears to be essential catalyze smooth formation of nitrosylsulfuric acid. In its absence, reaction may be delayed and then proceed explosively.
Thiophene. Violent reaction with fuming HNO_3.
Wood. Concentrated HNO_3 may ignite sawdust and fuming HNO_3, wood.

Physiological Properties and Health Hazards:

Vapor irritates respiratory system, eyes and skin. Liquid burns eyes and skin. Swallowing causes internal irritation and damage.
Avoid breathing vapor. Prevent contact with eyes and skin.

Spillage Disposal:

Instruct others to keep at a safe distance. Wear breathing apparatus and gloves. Spread sodium carbonate liberally over the spillage and mop up cautiously with water. Run this to waste, diluting greatly with running water.

Waste Disposal:

Wear rubber gloves, self-contained breathing apparatus, laboratory coat. Have body shield available.
Add slowly to large volume of agitated solution of sodium carbonate and calcium hydroxide. Add neutralized solution to large excess of running water.

Storage:

Store with mineral acids in a cool, well ventilated cupboard separate from oxidizing materials, organic acids or bases. Do not store near HBr or HI.

Handling:

Wear safety glasses and gloves. Handle concentrated acid with care.

Program References:

Biology: Investigations in Biology (Benson *et al.*), Investigation 1, 38, 41.
Alchem 20: I3(D).
Alchem 30: N3(D).
Keys to Chemistry: 4-1, 6-5, 11-1, 11-2.
Chemistry: Experiments and Principles, (Davis *et al.*), Ex. 10, 21, 22, 29, 30, 31, 36, 43.

NITRITES NO_2^-

CONTACT WITH COMBUSTIBLE MATERIAL MAY CAUSE FIRE. HARMFUL IF TAKEN INTERNALLY.

See POTASSIUM NITRITE
SODIUM NITRITE

NITROBENZENE $C_6H_5NO_2$

CARCINOGENICITY UNKNOWN.
SERIOUS RISK OF POISONING BY INHALATION, SWALLOWING OR SKIN CONTACT.
DANGER OF CUMULATIVE EFFECTS

Physical Properties:
Pale yellow oily liquid with odor of bitter almonds; bp 210–211°C.

Fire Hazard:
Combustible. Flash point 88°C. Ignition temp 482°C Extinguish with water, dry chemical, or carbon dioxide.

Chemical Properties:
Immiscible with water.

Hazardous Reactions:
Alkali. Heating nitrobenzene with sodium hydroxide, potassium hydroxide and small quantities of water may result in an explosion.
Aluminum trichloride. Mixtures of aluminum trichloride and nitrobenzene may decompose explosively. The presence of 5% phenol in the mixture may cause a violent explosion.
Aniline, Glycerol and Sulfuric acid. The preparation of quinoline by the Skraup reaction may be violent unless adequate stirring and temperature control are maintained.
Oxidants. Mixtures of nitrobenzene with sodium chlorate, or nitric acid, or nitric acid and water are powerful explosives. Nitration of nitrobenzene with nitric and sulfuric acids may be explosive without adequate temperature control.
Phosphorus pentachloride. A solution in nitrobenzene decomposes violently above 120°C.
Potassium. Mixtures of traces of potassium or sodium–potassium alloy and nitrobenzene are extremely shock–sensitive.

Physiological Properties and Health Hazards:
Liquid causes eye damage. Breathing vapor may result in chest pain, breathing difficulty and finally unconsciousness. Swallowing or skin absorption may result in vomiting and unconsciousness.
Avoid breathing vapor. Avoid contact with skin and eyes.

Spillage Disposal:
Instruct others to keep at a safe distance. Wear breathing apparatus and gloves. Absorb on paper towels. Place in separate labelled container for disposal by burning. Site of spillage should be washed thoroughly with water and soap.

Waste Disposal:
Place in non–halogenated solvent disposal container for disposal by burning.

p-NITRODIPHENYL (p-nitrobiphenyl) $C_6H_5-C_6H_4NO_2$

ANIMAL CARCINOGEN

Physical Properties:
Yellow needles; mp 114°C.

Chemical Properties:
Insoluble in water.

Physiological Properties and Health Hazards:
An experimental carcinogen by oral route.

Spillage Disposal:
Wear rubber gloves, protective laboratory coat.
On skin. Wash with strong soap solution immediately. Rinse well.
Sweep solid spills onto paper. Follow waste disposal. Wash the site thoroughly with strong soap solution.

Waste Disposal:
Place in a separate labelled container for disposal by burning.

1-NITRONAPHTHALENE $C_{10}H_7NO_2$

Physical Properties:
Yellow crystals; mp 59–61°C.

Chemical Properties:
Insoluble in water.

Spillage Disposal:
Wear rubber gloves, protective laboratory coat.
On skin. Wash with strong soap solution immediately. Rinse well.
Sweep solid spills onto paper. Follow waste disposal. Wash the site thoroughly with strong soap solution.

Waste Disposal:
Place in a separate, labelled container for disposal by burning.

2-NITROPROPANE

$CH_3CHNO_2CH_3$

SUSPECTED ANIMAL CARCINOGEN

Physical Properties:
Liquid mp −93°C; bp 120.3°C.

Fire Hazard:
Flash point 28°C; ignition temperature 428°C.
Extinguish with water, dry chemical or carbon dioxide.

Chemical Properties:
Slightly soluble in water.

Physiological Properties and Health Hazards:
An experimental carcinogen by inhalation route.

Spillage Disposal:
Wear neoprene gloves, plastic laboratory coat. Provide good ventilation.
Eliminate all sources of ignition.
On skin. Wash immediately with soap solution. Rinse thoroughly.
On clothing. Remove clothing immediately and place in a fume hood. Wash clothing before wearing again. Shoes are difficult to decontaminate and may have to be discarded and burned.
On bench and floor. Cover with sodium carbonate. Mix and spray with water. Scoop into a bucket of water. Let stand two hours. Neutralize with 6*M* HCl and wash into sewer with large excess of water. Wash site with soap solution.

Waste Disposal:
Place in a separate labelled container for disposal by burning.

NITROSAMINES R_2NNO

ANIMAL CARCINOGENS

Physiological Properties and Health Hazards:

These compounds are suspected to be causes of cancers of the lung, nasal sinuses, brain, esophagus, stomach, liver, bladder and kidney.

Spillage Disposal:

Wear butyl rubber gloves, protective laboratory coat, self-contained breathing apparatus, protective shoes.

On skin. Wash with strong soap solution immediately. Rinse well.

Contaminated gloves, clothing, shoes. Remove and clean at once or destroy by burning.

Small spills on tables or floor. Absorb liquid spills on paper towels or vermiculite; sweep solid spills onto paper. Put on an iron pan in the fume hood and allow to evaporate. Burn the paper or vermiculite in the absence of other flammables. Wash the site thoroughly with strong soap solution.

Large spills. Absorb or mix with vermiculite, sodium bicarbonate or sand. Package this in paper carton for disposal by burning. Wash site thoroughly as above.

Waste Disposal:

Place in a separate labelled container for disposal by burning.

N-NITROSODIMETHYLAMINE $(CH_3)_2NNO$

ANIMAL CARCINOGEN

Physical Properties:
Yellow liquid; bp 151–153°C.

Chemical Properties:
Very soluble in water.

Physiological Properties and Health Hazards:
Has caused fatal poisoning, severe liver injury.

Spillage Disposal:
Cover with sodium carbonate, mix and spray with water. Scoop into a bucket of water and allow to stand at least 2 h. Neutralize with 6*M* HCl and pour to drain greatly diluting with water.

Waste Disposal:
Place in a separate labelled container for disposal by burning.

NITROSOPHENOLS HOC_6H_4NO

OF UNKNOWN CARCINOGENICITY

Physical Properties:
p–Nitrosophenol is pale yellow needles, browns 126°C, dec 144°C.

Fire Hazard:
p–Nitrosophenol burns explosively.

Chemical Properties:
p–Nitrosophenol is moderately soluble in water.

Hazardous Reactions:
Technical grade of *p*–nitrosophenol may explode on storage. *o*–Nitrosophenol explodes on heating while *p*–nitrosophenol may ignite spontaneously if nitrates were present in the sodium nitrite used for its preparation.
Acids. Contact with concentrated acids causes *o*–nitrosophenol to explode. The addition of sulfuric acid to *p*–nitrosophenol containing nitrate impurities results in effervescence or ignition and can be used as a test for the presence of these impurities.

Physiological Properties and Health Hazards:
p–Nitrosophenol can cause skin irritation and sensitization.

Waste Disposal:
Place in a separate labelled container for disposal by burning.

OXALIC ACID

HOOCCOOH

HARMFUL IF TAKEN INTERNALLY

Hazard Rating:
Health 1; Fire 1; Reactivity 0.

Physical Properties:
Colorless crystals. Dihydrate mp 101–102°C. Anhydrous mp 189.5°C (dec), sublimes at 157°C.

Chemical Properties:
Soluble in water.

Hazardous Reactions:
Silver. Silver oxalate explodes at 140°C.

Physiological Properties and Health Hazards:
Dust irritates respiratory system and the eyes. Splashing of a solution into the eyes also causes irritation. Swallowing causes severe internal pain and collapse.
Avoid contact with the eyes and skin.

Spillage Disposal:
Wear face shield or goggles, and gloves. Cover with sodium bicarbonate. Mix and add water. Mop up with plenty of water and run to waste, diluting greatly with running water.

Waste Disposal:
Place in a separate, labelled container for disposal by burning.

Storage:
Store in general chemical stores.

Handling:
Wear safety glasses.

Program References:
Alchem 30: N3(D).
Chemistry: Experiments and Principles, (Davis *et al.*), Ex. 33.

PENTACHLOROPHENOL AND SODIUM PENTACHLOROPHENATE C_6Cl_5OH, C_6Cl_5ONa

SERIOUS RISK OF POISONING BY INHALATION, SWALLOWING OR SKIN CONTACT. CAUSES IRRITATION OF SKIN AND EYES.

Hazard Rating:
Health 3; Fire 0; Reactivity 0.

Physical Properties:
Pentachlorophenol is a colorless to yellow crystalline solid with a phenolic (carbolic) odor; mp 190–191°C. The sodium salt is a buff powder or flaked solid.

Chemical Properties:
Pentachlorophenol is insoluble in water. Sodium salt is soluble in water.

Physiological Properties and Health Hazards:
Dust of both compounds irritates the nose and eyes. Swallowing or absorption through the skin may cause feverishness and weakness, finally convulsions and unconsciousness. Avoid breathing dust. Prevent contact with skin and eyes.

Spillage Disposal:
Wear face shield or goggles, and gloves. Sweep up spills into metal container. Follow waste disposal. Wash site with soap solution.

Waste Disposal:
Place in a separate labelled container for disposal by burning.

Storage:
Store in general chemical stores.

Handling:
Wear safety glasses and gloves. Use fume hood.

PERCHLORATES ClO_4

EXPLOSIVE WHEN MIXED WITH COMBUSTIBLE MATERIAL

Physical Properties:

The perchlorates of ammonium, magnesium, sodium and potassium are colorless crystalline solids, all except that of potassium being readily soluble in water. Ammonium perchlorate is explosive when dry.

Fire Hazard:

Mixtures of inorganic perchlorates with combustible materials are readily ignited; mixtures with finely divided combustible materials frequently react explosively. Organic perchlorates are self-contained explosives.

Chemical Properties:

SAFE HANDLING OF PERCHLORATES

Schumacher states that:

"Perchlorates appear to fall into two broad categories: those more or less sensitive to heat and shock. Included in the group of those qualitatively less sensitive are pure ammonium perchlorate, the alkali metal perchlorates, the alkaline earth perchlorates, and perchloryl fluoride. Among the more sensitive compounds are the pure inorganic nitrogenous perchlorates, the heavy metal perchlorates, fluorine perchlorate, the organic perchlorate salts, the perchlorate esters, and mixtures of any perchlorates with organic substances, finely divided metals, or sulfur. Any attempt to establish a more precise order of the degree of hazard to be expected from any given perchlorate seems unwarranted on the basis of data available. Each perchlorate system must be separately (and cautiously) evaluated.

"There do not appear to be any uniform recommendations for the safe handling of perchlorates which are generally applicable. A number of heavy metal and organic perchlorates, as well as hydrazine perchlorate (hydrazinium diperchlorate) and fluorine perchlorate, are extremely sensitive and must be handled with great caution as initiating explosives. Mixtures of any perchlorates with oxidizable substances are also highly explosive and must be treated accordingly. For all of these, it is essential to avoid friction, heating, sparks, or shock from any source (as well as heavy metal contamination), and to provide suitable isolation, barricades and protective clothing for personnel."

However, "the more common ammonium, alkali metal, and alkaline earth perchlorates are considerably less hazardous."

Synthesis of new inorganic or organic perchlorates should only be undertaken by an experienced, cautious, investigator who is familiar with the literature.

A simple test to evaluate impact sensitivity can be conducted by placing a crystal or two of the perchlorate on a steel block and striking with a hammer. The degree of noise and relative impact to produce the explosion can be roughly correlated with the impact sensitivity.

A simple thermal stability test can be conducted by placing a crystal or two on a hot plate and observing the time to create a violent decomposition reaction. A gram of the material can be heated slowly in a loosely-closed vial for more exact determination of thermal stability.

Hazardous Reactions:

See Fire Hazard.

All organic perchlorates are self-contained explosives; mixtures of inorganic perchlorates with combustible materials are readily ignited; mixtures with finely divided combustibles frequently react explosively.

Physiological Properties and Health Hazards:

Avoid contact with combustible materials. Avoid contact with skin, eyes and clothing.

The dust and strong solutions will irritate the skin, eyes and respiratory system. They are also irritant and harmful if taken internally.

PERCHLORIC ACID $HClO_4$

CONTACT WITH COMBUSTIBLE MATERIAL MAY CAUSE FIRE. CAUSES BURNS.

Hazard Rating:

Health 3; Fire 0; Reactivity 3

Physical Properties:

Colorless, volatile, very hygroscopic liquid; miscible with water; sold commercially only as 60–70%.

Fire Hazard:

Anhydrous acid (which may be formed with strong dehydrating agents) decomposes at ordinary temperatures and explodes on contact with most organic materials. Extinguish with water spray.

Chemical Properties:

Very hygroscopic. Combines vigorously with water with evolution of heat. Undergoes spontaneous and explosive decomposition. Very caustic.

Acid Handling

85% PERCHLORIC ACID OR LESS

1. Use goggles for eye protection whenever the acid is handled.
2. Always transfer acid over a sink in order to catch any spills and afford a ready means of disposal.
3. In wet combustions with perchloric acid, treat the sample first with nitric acid to destroy easily oxidizable matter.
4. Any procedure involving heating of the perchloric acid must be conducted in a ventilated hood.
5. No organic materials should be stored in the perchloric acid hood.
6. Do not allow perchloric acid to come in contact with strong dehydrating agents (concentrated sulfuric acid, anhydrous phosphorus pentoxide, etc.).
7. Perchloric acid should be used only in standard analytical procedures from well recognized analytical texts. (This does not apply to analytical research workers.)

ANHYDROUS PERCHLORIC ACID (GREATER THAN 85%)

1. Only experienced research workers should handle anhydrous perchloric acid. These workers must be thoroughly familiar with the literature on the acid.
2. A safety shield must be used to protect against a possible explosion, and the acid must be used in an appropriate hood with a minimum of equipment present. No extraneous chemicals should be present in the hood.
3. A second person should be informed of the intended use of anhydrous acid and be in the same room with the research worker using this extremely strong oxidizer.
4. Safety goggles, face shield, thick gauntlets, and rubber apron must be worn.
5. Only acid freshly prepared should be used.
6. Dispose of the unused anhydrous acid at the end of each day.
7. Do not make any more anhydrous perchloric acid than is required for a single day's work.
8. Contact of the anhydrous acid with organic materials will usually result in an explosion.
9. Anhydrous acid showing any discoloration should be disposed of immediately.

Hazardous Reactions:

Exceptionally powerful oxidizing agent which readily forms explosive salts. Safe handling procedures have been described.

Acetic anhydride, Acetic acid, Organic Materials. Anhydrous $HClO_4$ is formed in the presence of acetic anhydride; the mixture is sensitive to shock and heat and may explode violently in the presence of organic material.

Acetic anhydride, Carbon tetrachloride, 2-Methylcyclohexanone. During acetylation of the enolized ketone, the 70% perchloric acid must be added last.

Alcohols. Explosions occurred during reactions with traces of methanol–chloroform or ethanol; partial esterification of polyfunctional alcohols with the anhydrous acid gives liquids which may explode on pouring.

Aniline, Formaldehyde. Explosive resin formed from mixture.
Antimony or Bismuth. Treatment of antimony(III) compounds or bismuth can be very hazardous.
Carbon. Violent explosion occurs between the anhydrous acid and wood charcoal or carbon black.
Cellulose and Derivatives. Hot concentrated acid or cold anhydrous acid on paper, wood fiber or sawdust, ignites; long-term contact of dilute acid with wood may cause fire; explodes on contact with cellulose acetate or benzyl cellulose.
Dehydrating Agents. Dehydration of 72% acid by heating with H_2SO_4, P_2O_5 or H_3PO_3 or by distillation under reduced pressure yields anhydrous perchloric acid which explodes after storage at room temperature for 30 days; mixtures with excess cold acetic anhydride are particularly dangerous since they are sensitive to mechanical shock, heat, or the introduction of organic contaminants; chloroform solution of the monohydrate exploded on contact with P_2O_5; methylene chloride is a safer solvent for preparing anhydrous solutions.
Deoxyribonucleic acid. Hydrolysis using $HClO_4$ is hazardous.
Diethyl ether. Anhydrous acid and ether may explode on contact.
Thallium triacetate. Pasty residue from evaporation of mixture of thallium triacetate, acetic acid, perchloric acid and ethyl benzene exploded.
Glycols and their Ethers. Perchloric acid (70%) decomposes glycols and their ethers violently.
Iodides. Anhydrous $HClO_4$ ignites on contact with NaI or HI.
Ketones. Ketones may undergo violent decomposition in contact with 70% acid.
Methanol, Triglycerides. Transesterification of triglycerides in methanol using $HClO_4$ is hazardous.
Nitric acid, Organic matter. The use of the mixed acids to digest organic matter may result in explosions. Explosions with vegetable oil, milk, calcium oxalate precipitates from plants, rat carcasses, finely ground plant material, animal tissues have been documented.
Nitric acid, Pyridine, Sulfuric acid. Formation of pyridinium perchlorate presents an explosion hazard during wet-ashing of rare earth fluorides.
Nitrogenous epoxides. Traces of $HClO_4$ used for ring opening of nitrogenous epoxides caused explosion.
Oleic acid. Preparation of 1,4-octadecanolactone from oleic acid by heating with 70% $HClO_4$ at 115°C is potentially dangerous.
Phosphine. Salt formed with 60% $HClO_4$ at −20°is dangerously explosive.
Sodium phosphinate. No interaction in the cold, but violent explosion occurs on heating.
Sulfoxides. Lower members of the series of salts formed with organic sulfoxides are explosive when dry.
Trichloroethylene. Violent reaction occurs with anhydrous $HClO_4$.

Physiological Properties and Health Hazards:

Burns the eyes and skin severely. Assumed to cause severe internal irritation and damage if taken by mouth.
Prevent contact with eyes and skin.

Spillage Disposal:

Perchloric acid spilled on the floor or bench top presents a hazard. It should not be mopped up, nor dry combustibles used to soak up the acid. The spilled acid should first be neutralized and then soaked up with rags or paper towels. The contaminated rags and paper towels must be kept wet to prevent combustion upon drying. They should be placed in a plastic bag and sealed and then placed in a flammable waste disposal can. If the spill can be rinsed down a chemical drain, neutralization of the wetted area is recommended, followed by additional rinsing.

Wear face shield and gloves. Cover with weak reducing sodium thiosulfate or sodium bisulfite. Transfer the slurry or sludge into a large container of water and neutralize with sodium carbonate. Drain into sewer with abundant water.

Waste Disposal:

A small amount of perchloric acid can be dumped into a sink and flushed down with at least 10 times its volume of water.

In the fume hood, behind a shield, slowly and cautiously, with stirring, add to a vast volume of concentrated sodium thiosulfate solution. Neutralize and drain to sewer with excess water.

Storage:

Store away from all flammable, organic and combustible materials, strong oxidants, reductants and dehydrating agents. The container should be surrounded by enough inert inorganic packing material to absorb the acid in the event of damage.

Handling:

See Chemical Properties.

PEROXIDES ROOR

EXPLOSIVE
See also alphabetical listing for HYDROGEN PEROXIDE.

Storage:
Inorganic peroxides should be stored with other oxidizing agents in tightly closed containers. Note that hydrogen peroxide solution should not be tightly closed. Organic peroxides should be stored in an explosion proof refrigerator away from easily oxidized materials.

Handling:
Wear safety glasses and gloves.

Program References:
Sodium peroxide: Physical Science, An Introductory Study, (Andrews, Wolfe and Eix), 9.8, p. 233; omit procedure A.

PHENANTHRENE $C_{14}H_{10}$

MAY SENSITIZE THE SKIN TO LIGHT

Physical Properties:
Monoclinic plates; mp 100°C.

Chemical Properties:
Practically insoluble in water.

Physiological Properties and Health Hazards:
Can cause photosensitization of skin. An experimental carcinogen by dermal route.

Spillage Disposal:
Sweep onto paper and package. Follow waste disposal.

Waste Disposal:
Place in a separate labelled container for disposal by burning.

PHENOL (carbolic acid) C_6H_5OH

TOXIC IF TAKEN INTERNALLY. CAUSES BURNS.

Hazard Rating:
Health 3; Fire 2; Reactivity 0.

Physical Properties:
Colorless crystalline substance with distinctive odor; reddens on exposure to air and light; mp 43°C.

Chemical Properties:
1 g dissolves in about 15 mL water at 25°C.

Hazardous Reactions:
Aluminum trichloride and Nitrobenzene. Mixtures of aluminum trichloride, nitrobenzene and phenol react violently at 120°C.
Formaldehyde. Preparation of phenol–formaldehyde resins can result in uncontrollable reactions.
Sodium nitrite. A heated mixture with phenol exploded violently.

Physiological Properties and Health Hazards:
Vapor irritates respiratory system and eyes. Solid burns skin. It is readily absorbed through the skin and causes headache, dizziness, weakness and collapse. Swallowing causes severe internal damage, pain, nausea and vomiting. Prolonged inhalation of the vapor results in disruption of the digestive and nervous systems, skin eruptions and damage to the liver and kidneys.
Avoid breathing vapor. Avoid contact with skin and eyes.

Spillage Disposal:
Wear face shield or goggles, and gloves. Eliminate all sources of ignition. Sweep onto paper. Follow waste disposal procedure.
Site of spillage should be washed thoroughly with water and soap.

Waste Disposal:
Place in a separate labelled container for disposal by burning.

Storage:
Store with organic acids in a cool, dry cupboard.

Handling:
Wear eye protection and gloves.

PHENYL AZIDE $C_6H_5N_3$

EXPLOSIVE

Hazard Rating:
Health 3; Fire 2; Reactivity 2.

Physical Properties:
Liquid, bp 41–43°C/5mm. Phenyl azide explodes when heated at ordinary pressure and occasionally at a lower pressure. The distillation of phenyl azide must be carried out behind an explosion-proof screen.

Fire Hazard:
Explodes on heating.

Hazardous Reactions:
Explodes when heated at atmospheric pressure.
Lewis Acids. Vigorous or violent decomposition with H_2SO_4 and Lewis acids.

Spillage Disposal:
Sponge up with water, followed by decontamination with a 10% ceric ammonium nitrate solution.

Waste Disposal:
Wear leather gloves, heavy face shield and laboratory coat. Work from behind body shield. Avoid unnecessary heat, friction or impact. "Kill" by adding to a greater-than-stoichiometric amount of ceric ammonium nitrate solution with agitation sufficient to provide suspension of all solids. Cool the reaction.

Storage:
EXPLOSIVE. Do not store.

Handling:
Wear safety glasses and gloves. Work from behind a body shield.

N-PHENYL-*beta*-NAPHTHYLAMINE

$C_{10}H_7NHC_6H_5$

ANIMAL CARCINOGEN

Physical Properties:

Needle-like crystals; mp 108°C.

Chemical Properties:

Emits highly toxic fumes when heated to decomposition; can react with oxidizing materials. An experimental carcinogen by oral and subcutaneous routes.

Spillage Disposal:

Wear rubber gloves, laboratory coat.

On skin and clothing. Wash skin with strong soap solution immediately. Rinse thoroughly. Contaminated clothing should be removed, dried, and washed with strong soap solution, or destroyed. It may be necessary to destroy shoes by burning.

Small spills. Brush onto paper. Package and follow waste disposal. Wash site with strong soap solution.

Waste Disposal:

Place in a separate, labelled container for disposal by burning.

PHENYLTHIOCARBAMIDE (phenylthiourea) $C_6H_5NHCSNH_2$

SEVERE POISON.

Physical Properties:
Bitter or tasteless needles, depending upon heredity of taster; mp 154°C.

Chemical Properties:
Soluble in 400 parts cold water, 17 parts boiling water; soluble in alcohol.

Spillage Disposal:
Wear face shield or goggles and gloves. Package and follow waste disposal procedure. Wash site of spillage with abundant water or soap and water.

Waste Disposal:
Place in separate labelled container for disposal by burning.

Storage:
Store in general chemical stores.

Handling:
Wear safety glasses and gloves.

Program References:
Life Science: A Problem-Solving Approach (Carter), Ch. 18-2, p. 349.
Biology BSCS Yellow version, 32.1.

Neither phenylthiocarbamide nor phenylthiocarbamide paper should be tasted.

PHOSPHINE (hydrogen phosphide) PH_3

EXTREMELY FLAMMABLE. TOXIC BY INHALATION.

Physical Properties:

Colorless gas with smell somewhat like that of rotting fish; bp −87.7°C.

Chemical Properties:

Slightly soluble in water. With a trace of P_2H_4 present, phosphine is spontaneously flammable in air, burning with a luminous flame.

Hazardous Reactions:

Liquefied phosphine is detonable.

Air. Dry phosphine ignites in air at room temperature. Small traces of impurities such as diphosphane, dinitrogen trioxide, nitrous acid or other oxidant cause phosphine to ignite at temperatures below −15°C.

Halogens. Phosphine ignites on contact with chlorine, bromine or their aqueous solutions.

Metal Nitrates. Ignition of the gas or explosion occurs when phosphine is bubbled into concentrated silver nitrate solution. With mercury(II) nitrate a complex phosphide, explosive when dry, is formed.

Nitric acid. Phosphine is oxidized explosively by fuming nitric acid and ignites when fuming acid is dripped into the gas.

Oxygen. Phosphine–oxygen mixtures are explosive.

Physiological Properties and Health Hazards:

Breathing gas results in chest pain, weakness, damage to the lungs, coma and finally death.

Prevent inhalation of gas.

Fire Hazard:

Impure phosphine must be regarded as spontaneously flammable. Since the gas is supplied in a cylinder, turning off the valve will reduce any fire involving it; if possible, cylinders should be removed quickly from an area in which a fire has developed.

Waste Disposal:

Strictly avoid moist air. Wear rubber gloves, protective clothing and self–contained breathing apparatus.

Surplus gas or leaking cylinder can be vented slowly to air in a safe, open area or gas burnt off through a suitable burner in a fume cupboard.

Storage:

Store cylinders upright and tightly secured in fume hood or well ventilated area.

Handling:

Strictly avoid moist air. Wear safety glasses and gloves. Use fume hood.

PHOSPHORUS, Red and White (Yellow) P

RED: HIGHLY FLAMMABLE. EXPLOSIVE WHEN MIXED WITH OXIDIZING SUBSTANCES.
WHITE (YELLOW): SPONTANEOUSLY FLAMMABLE IN AIR. SERIOUS RISK OF POISONING BY INHALATION OR SWALLOWING.

Hazard Rating:

White (Yellow): Health 3; Fire 3; Reactivity 1.
Red: Health 0; Fire 1; Reactivity 1.

Physical Properties:

Red (amorphous) phosphorus sublimes at 416°C; white (yellow) phosphorus is a pale yellow, waxy, translucent solid; mp 44°C; usually stored under water.

Fire Hazard:

Water is the best medium for fighting a phosphorus fire caused by its spontaneous ignition.

Chemical Properties:

Red phosphorus is insoluble in water. White phosphorus ignites rapidly in air giving off fumes of the oxide.

Hazardous Reactions:

Red phosphorus may ignite on impact.
Alkalies. Contact of phosphorus with boiling caustic alkalies or with hot calcium hydroxide produces phosphine which can ignite in air.
Halogens and Interhalogens. White and red phosphorus ignite on contact with fluorine or chlorine and red ignites in liquid bromine. White phosphorus explodes in liquid chlorine or bromine and ignites in bromine vapor or solid iodine.
Hydriodic acid. The use of red phosphorus and hydriodic acid as a reducing agent for organic carbonyl compounds is potentially hazardous.
Hydrogen peroxide. If white or red phosphorus is not completely immersed while undergoing oxidation in H_2O_2 solutions (30% or stronger), it may ignite and cause a violent reaction.
Magnesium perchlorate. Mixtures may explode violently.
Metal Halogenates. Dry, finely divided mixtures of red or white phosphorus and chlorates, bromates or iodates of barium, calcium, magnesium, potassium, sodium or zinc explode when subjected to friction, impact or heat. Mixtures of potassium iodate with white or red phosphorus react violently or explosively on addition of a small quantity of water.
Metal Halides. Phosphorus ignites in contact with antimony pentafluoride and explodes with chromyl chloride when moist.
Metal Oxides. Red phosphorus reacts vigorously on heating with copper oxide or manganese dioxide. It may ignite on grinding or warming with lead monoxide or mercury or silver oxides. It ignites in contact with lead, sodium or potassium peroxides. White phosphorus explodes in contact with the latter peroxides.
Metals. Beryllium, manganese, thorium and zirconium react with incandescence when heated with phosphorus. Cerium, lanthanum, neodymium and praseodymium react violently above 400°C. Osmium incandesces in phosphorus vapor and platinum burns vividly.
Nitrates. White phosphorus ignites in molten ammonium nitrate and mixtures with ammonium, mercury(I) or silver nitrates explode on impact.
Nitric acid. The vapor from phosphorus heated in HNO_3 may ignite.
Non-Metal Halides. White and red phosphorus incandesce with boron triiodide. White phosphorus explodes with seleninyl chloride. Red phosphorus incandesces in seleninyl chloride and reacts vigorously on warming with sulfuryl or disulfuryl chlorides and violently with disulfur dibromide.
Non-Metal Oxides. Warm or molten white phosphorus burns vigorously in nitrogen oxide, dinitrogen tetroxide or pentoxide and ignites in sulfur trioxide vapor or liquid.
Oxygen. Finely divided white phosphorus ignites in air. Contact with charcoal or amalgamated aluminum promotes ignition.
Potassium permanganate. Mixtures of phosphorus and potassium permanganate explode on grinding.
Selenium. Mixture incandesces on warming.

Sulfur. White phosphorus ignites on contact with sulfur and explodes on heating. Red phosphorus may ignite on mixing and cause a violent reaction.
Sulfuric acid. White phosphorus ignites in contact with boiling H_2SO_4 or its vapor.

Physiological Properties and Health Hazards:
Red phosphorus is not considered to be harmful physiologically. White phosphorus burns the skin and eyes and causes severe internal damage if swallowed. The vapor from burning phosphorus irritates the respiratory system and eyes. Prolonged absorption of small quantities results in anemia, intestinal weakness and bone and liver damage.
Avoid contact with skin and eyes.

Spillage Disposal:
Red form: Moisten with water, shovel into a bucket, transport to a safe, isolated area where the moisture can be allowed to dry off and the phosphorus burnt off. This applies to small spillages only.
Yellow or White form: Wear face shield or goggles, and gloves; cover with wet sand, shovel into bucket and remove to safe, open, isolated area where the phosphorus can be burnt off under supervision after drying out. Small spillages of phosphorus can be burnt off in a fume cupboard.

Waste Disposal:
Put the package under water in a large container. Repackage in the water for disposal.

Storage:
Red Phosphorus: Store in a cool place separate from alkalies and both oxidizing or reducing agents.
Yellow Phosphorus: Store under water separated from other materials.

Handling:
Red Phosphorus: Wear safety glasses and gloves.
Yellow Phosphorus: Wear safety glasses and gloves. Handle with forceps. Never expose large pieces to the air. Cutting should be done under cold water.

Program References:
Alchem 10: A2; omit, or use red phosphorus as sample.

PHOSPHORUS PENTACHLORIDE PCl_5

IRRITANT VAPOR AND DUST. CAUSES BURNS

Hazard Rating:
Health 3; Fire 2.

Physical Properties:
White to pale yellow, fuming, deliquescent, crystalline masses with pungent, unpleasant odor.

Chemical Properties:
Violently decomposed by water with formation of hydrochloric acid and phosphoric acid.

Hazardous Reactions:
Aluminum. Ignites on contact with Al powder.
Carbamates. Unstable salts formed between carbamates and PCl_5 which may decompose explosively.
Chlorine dioxide, Chlorine. Explodes on contct with mixture of chlorine dioxide and chlorine.
Diphosphorus trioxide. Violent interaction at room temperature.
Fluorine. Ignites on contact.
Hydroxylamine. Ignites on contact.
Nitrobenzene. Solution decomposes violently above 120°C.
Urea. Dry mixture explodes after heating.
Water. Reacts violently with water.

Physiological Properties and Health Hazards:
Avoid breathing vapor and dust. Prevent contact with eyes and skin.
Vapor and dust severely irritate the mucous membranes and all parts of the respiratory system. The vapor severely irritates and the solid burns the eyes The vapor and solid burn the skin. If taken by mouth there would be severe internal irritation and damage.
Chronic Effects. Continued exposure to low concentrations of vapor may cause damage to lungs.

Spillage Disposal:
Wear goggles and gloves. Mix with dry sand, shovel into an enamel or polythene bucket. In the fume hood add, a little at a time, to a large volume of water; after reaction is complete neutralize to pH 7 and run to waste, diluting greatly with running water. Dispose of sand as normal refuse Cover site with $NaHCO_3$. Add water cautiously at first, then wash spillage site with water.

Waste Disposal:
In the fume hood behind a safety shield *cautiously* add a little at a time to a large volume of water containing 5% $NaHCO_3$. After adjusting the pH of the resulting solution to 7, wash down the drain.

Storage:
Store with other metal halides in a well-ventilated, dry area in a tightly closed container.

Handling:
Wear safety glasses and gloves. Work in fume hood.

PHOSPHORUS TRICHLORIDE PCl_3

HARMFUL VAPOR. CAUSES BURNS. IRRITATING TO SKIN, EYES AND RESPIRATORY SYSTEM.

Hazard Rating:
Health 3; Fire 0; Reactivity 2.

Physical Properties:
Colorless fuming liquid; bp 76°C.

Chemical Properties:
Violently decomposed by water, forming hydrochloric acid and phosphorous acid.

Hazardous Reactions:
Acetic acid. Residue in preparation of acetyl chloride from PCl_3 and acetic acid may decompose violently with evolution of flammable phosphine.
Carboxylic Acids. Use of PCl_3 as chlorinating agent for carboxylic acids may result in explosion when product is distilled.
Dimethyl sulfoxide. Reacts explosively with PCl_3.
Hydroxylamine. Ignites on contact with PCl_3.
Metals. K ignites in PCl_3; molten Na explodes on contact.
Nitric or Nitrous acids. Explodes on contact with either acid.
Water. Reacts violently on contact with water with liberation of some diphosphane which ignites.

Physiological Properties and Health Hazards:
Vapor severely irritates the mucous membranes and all parts of the respiratory system. The vapor and liquid burn the eyes and skin. Assumed to cause severe internal irritation and damage if taken by mouth.
Chronic Effects. Continued exposure to low concentrations of vapor may cause lung damage.
Avoid breathing vapor. Prevent contact with eyes and skin.

Spillage Disposal:
Wear goggles and gloves. Mix with dry sand, shovel into an enamel or polythene bucket. In the fume hood add, a little at a time, to a large volume of water; after reaction is complete neutralize to pH 7 and run to waste, diluting greatly with running water. Dispose of sand as normal refuse. Cover site with $NaHCO_3$. Add water cautiously at first, then wash spillage site with water.

Waste Disposal:
In the fume hood behind a safety shield *cautiously* add a little at a time to a large volume of water containing 5% $NaHCO_3$. After adjusting the pH of the resulting solution to 7, wash down the drain.

Storage:
Store with other metal halides in a well-ventilated dry area in a tightly closed container.

Handling:
Wear safety glasses and gloves. Work in fume hood.

PICRIC ACID $(NO_2)_3C_6H_2OH$

RISK OF EXPLOSION BY SHOCK, FRICTION, FIRE OR OTHER SOURCE OF IGNITION. FORMS VERY SENSITIVE EXPLOSIVE METALLIC COMPOUNDS. HARMFUL IF TAKEN INTERNALLY.

Picric acid (yellow crystals) should be kept moist with not less than half its own weight of water. It is commonly used in alcoholic solutions in the laboratory.

Hazard Rating:
Health 2; Fire 4; Reactivity 4.

Physical Properties:
Pale yellow, odorless, intensely bitter crystals, mp 122–123°C. Explodes above 300°C.

Fire Hazard:
Explosive, ignition temp less than 300°C, oxidizing agent.

Hazardous Reactions:
Explosive which is usually stored as water–wet paste.
Salts. Forms salts with many metals, some of which (Pb, Hg, Cu, or Zn) are sensitive to heat, friction or impact; contact of acid with concrete floors may form friction–sensitive Ca salt.

Physiological Properties and Health Hazards:
Skin contact may result in dermatitis. Poisonous if taken by mouth.
Chronic Effects. Absorption through the skin or inhalation of dust over a long period may result in skin eruptions, headache, nausea, vomiting or diarrhea; the skin may become yellow.
Avoid contact with skin and eyes.

Spillage Disposal:
Wear face shield or goggles, and gloves. Moisten well with water and mix with sand. Transport to isolated area for burial. Site of spillage must be washed thoroughly with water and detergent.

Waste Disposal:
An additional hazard of picric acid is that it explodes when heated rapidly or by percussion. This hazard is lessened by the addition of water and most picric acid which is available at present from various companies is sold as a moist solid. However, even this does not permanently remove the explosion hazard as the added water does evaporate upon prolonged storage. Thus, it is advisable to check for moisture content every few months in any bottles of picric acid which may be on hand, adding water as it appears necessary.

This water addition procedure should not be carried out indefinitely. Any picric acid which has remained on the shelf for more than two years should be destroyed, even if it remains moist.

Under no circumstances should dry picric acid be chemically decomposed as described above. The only safe method of decomposing dry picric acid is by controlled detonation.

Storage:
Explosive when dry. Do not store.

Handling:
Wear safety glasses and gloves. Work from behind a body shield.

POTASSIUM K

VIOLENT REACTION WITH WATER. CONTACT WITH WATER LIBERATES HIGHLY FLAMMABLE GASES. CAUSES BURNS.

Hazard Rating:
Health 3; Fire 1; Reactivity 2.

Physical Properties:
Soft silvery white metal, tarnishes on exposure to air; mp 63°C.

Fire Hazard:
A fire resulting from the ignition of potassium metal is best extinguished by smothering it with dry soda ash or dry chemical.

Chemical Properties:
Reacts violently with water with the formation of potassium hydroxide and hydrogen gas, which will ignite. Explosions have occurred when old heavily-crusted potassium metal has been cut with a knife. Such old stock should be disposed of by dissolving, uncut, in *tert*-butanol.

Hazardous Reactions:
Detailed laboratory procedures for the safe handling of K have been published.
Air. In contact with moist air, rapid oxidation occurs which may become so fast as to result in melting or ignition. On prolonged exposure to air a coating of yellow potassium superoxide (KO_2) is formed; percussion or dry cutting brings the metal in contact with the superoxide and a violent explosion occurs; K should be stored under dry xylene in airtight containers.
Alcohols. Reacts explosively with methanol, ethanol, *n*-propanol to *n*-octanol, benzyl alcohol and cyclohexanol unless air in the reaction vessel is displaced by N_2.
Carbon. Vigorous exothermic reaction with soot, graphite or activated charcoal.
Carbon disulfide. Mixtures explode on impact but not on heating.
Dimethyl sulfoxide. Violent interaction with potassium "sand".
Halocarbons. Mixtures of K and a wide range of halocarbons are shock sensitive and may explode violently. Explosions have been recorded with mono-, di-, tri-, tetra- and pentachloroethane, bromoform, dibromo- and diiodomethane, carbon tetrachloride, and tetrachloroethylene.
Halogens. Ignites in F_2 and dry Cl_2; incandesces in Br_2 vapor and on heating with I_2 and explodes violently in liquid Br_2.
Hydrazine. Explosive interaction.
Hydrogen iodide. Mixture is impact sensitive.
Mercury. Reaction to form amalgams is vigorous or violent.
Metal Halides. Reacts explosively or violently with the following: calcium bromide, iron(III) bromide or chloride, iron(II) bromide or iodide, cobalt(II) chloride, silver fluoride, all four mercury(II) halides, copper(I) chloride, bromide or iodide, copper(II) chloride and bromide, ammonium tetrachlorocuprate, zinc and cadmium chlorides, bromides and iodides, aluminum fluoride, chloride and bromide, thallium(I) bromide, tin(II) or (IV) chloride, tin(IV) iodide, arsenic trichloride and triiodide, antimony and bismuth trichlorides, tribromides and triiodides, vanadium(V) chloride, chromium(IV) chloride, manganese(II) and iron(II) chlorides,and nickel chloride, bromide and iodide.
Metal Oxides. Reacts explosively with lead peroxide and on warming with Cu(II) oxide, Hg(II) oxide and Hg(I) oxide, tin(IV) oxide and molybdenum(III) oxide.
Nitric acid. Explosive reaction with concentrated acid.
Non-Metal Halides. Reacts explosively or forms shock sensitive mixtures with diselenium dichloride and seleninyl chloride, PCl_3 vapor or liquid, sulfur dichloride or dibromide, PBr_3 and phosgene.
Non-Metal Oxides. Forms shock-sensitive mixtures with solid CO_2 and CO.
Oxidants. Reactions with oxidants are usually explosive.
Sulfuric acid. Reaction is explosive.
Water. Heat evolved is enough to ignite liberated hydrogen; large pieces of the metal explode on the surface of water, scattering burning particles over a wide area.

Physiological Properties and Health Hazards:

Reaction of the metal with skin moisture yields potassium hydroxide and can cause thermal and caustic burns of the skin and eyes.
Avoid contact with skin and eyes.

Waste Disposal:

The following procedure is recommended for the safe handling of potassium. The metal may be cut conveniently under xylene (which has been dried over sodium wire) contained in a mortar. A beaker or crystallizing dish should *not* be used because it is too fragile. Each scrap obtained in cutting off the outer oxide-coated surface of the metal should be immediately transferred with tweezers to a second deep mortar containing dry xylene,where the accumulated residues are decomposed as described below as soon as the cutting operation is completed In order to weigh the freshly cut metal it may be removed with tweezers, blotted rapidly with a piece of filter paper, and introduced into a tared beaker containing dry xylene. The weighed potassium is then introduced into the reaction mixture, the proper precautions such as exclusion of air and moisture and rate of addition being taken, depending on the nature of the reaction involved. *Caution*! it is the small scraps of metal that adhere to the knife or float on top of the xylene that are most likely to start a fire.

Danger! Potassium residues have been known to explode even when under a protective liquid. It is therefore important that all such residues be decomposed *immediately*; under no circumstances should they be stored. The mortar containing the scraps is moved to the rear of the hood and *tert*-butyl (not methyl or ethyl) alcohol is added in small portions from a medicine dropper or beaker at such a rate that the reaction does not become too vigorous. A square sheet of asbestos large enough to cover the mortar should be at hand. If the liquid should catch fire it may be extinguished easily by covering the mortar with the asbestos sheet. There should be no other inflammable material or flames in the hood during this treatment. Sufficient *tert*-butyl alcohol must be employed to ensure *complete* decomposition of all the potassium. Small specks of potassium usually remain in the first mortar used for the cutting operation; they should be decomposed in the hood by cautious addition of small amounts of *tert*-butyl alcohol as described above.

Larger quantities should be burned in an open furnace.

Storage:

Store under liquid paraffin beside reducing agents.

Handling:

See Waste Disposal.

POTASSIUM CHLORATE $KClO_3$

EXPLOSIVE WHEN MIXED WITH COMBUSTIBLE MATERIAL. HARMFUL IF TAKEN INTERNALLY.

Hazard Rating:
Health 1; Fire 0; Reactivity 2.

Physical Properties:
Colorless lustrous crystals; mp 368°C; soluble in water.

Fire Hazard:
Powerful oxidizing agent. Forms explosive mixtures with combustible materials. Extinguish with water.

Hazardous Reactions:
Ammonia or Ammonium sulfate. Vigorous reaction with high concentrations of NH_3; on heating, a mixture with $(NH_4)_2SO_4$ decomposes with incandescence.
Fabric. Fabric gloves (wrongly used in place of impervious plastic gloves), became impregnated during handling operations and subsequently ignited from cigarette ash.
Hydrocarbons. Violent explosions occur on mixing powdered potassium chlorate with hydrocarbons.
Hydrogen iodide. Molten potassium chlorate ignites HI gas.
Manganese dioxide. Explosion may occur on heating mixture.
Manganese dioxide and Potassium hydroxide. Mixture explodes on heating above 80 – 90°C at pressures above 19 kbar.
Metals. Sensitive explosives are formed by mixtures with finely divided Al, Cu, Mg or Zn. Mixtures with Cr, germanium, titanium and zirconium, incandesce or explode on heating.
Metal Sulfides. Sensitive explosives are formed with many metal sulfides.
Metal Thiocyanates. Mixtures are friction- and heat-sensitive.
Nitric acid, Organic Matter. In destroying organic matter prior to analysis not more than 0.3 g of chlorate should be added or explosive oxidation may result.
Non-Metals. Mixtures with arsenic, carbon, phosphorus, sulfur or other readily oxidized material may explode violently.
Sulfuric acid. Addition of $KClO_3$ in portions to H_2SO_4 below 60°C and above 200°C causes brisk effervescence; between these temperatures explosions are caused by the ClO_2 produced.

Physiological Properties and Health Hazards:
Swallowing may irritate the intestinal tract and kidneys.
Avoid contact with skin, eyes and clothing.

Spillage Disposal:
Shovel into bucket of water and run solution to waste, diluting greatly with running water. Site of spillage and clothing should be washed thoroughly to remove all oxidant.

Waste Disposal:
Wear rubber gloves. In the fume hood, *cautiously* and slowly add to a large excess of concentrated aqueous solution of sodium thiosulfate or sodium bisulfite. (Some 3*M* H_2SO_4 may be required to accelerate reaction.) After reaction is complete, adjust pH to 7, then drain to sewer with large amounts of water.

Storage:
Store separate from mineral acids, organic compounds, and ammonium salts. Immediately remove and dispose of any spilled chlorate. Do not store on wood.

Handling:
Wear gloves and face shield and work behind safety shield.

Program References:
Physical Science: A Problem-Solving Approach (Carter), Ch. 17-1; substitute PbO_2.

POTASSIUM CHROMATE K_2CrO_4

HUMAN CARCINOGEN AS DUST. CONTACT WITH COMBUSTIBLE MATERIAL MAY CAUSE FIRE. HARMFUL IF TAKEN INTERNALLY

Physical Properties:
Lemon-yellow crystals, mp 975°C.

Chemical Properties:
Soluble in water.

Physiological Properties and Health Hazards:
Dust irritates respiratory tract and eyes. Swallowing causes irritation and internal damage. Prolonged exposure causes ulceration, damage to liver and kidneys and even cancer. Avoid inhaling dust. Avoid contact with eyes and skin.

Spillage Disposal:
Cover with sodium thiosulfate or sodium bisulfite. Mix well and spray with water. Scoop slurry into a container of water and neutralize. Wash down drain with excess water.
Site of spillage should be washed thoroughly to remove all oxidant, which is liable to render any organic matter (particularly wood, paper and textiles) with which it comes into contact, dangerously combustible when dry. Clothing wetted with the solution should be washed thoroughly.

Waste Disposal:
Add to a large volume of concentrated solution of sodium thiosulfate, sodium bisulfite or a ferrous salt and acidify with $3M$ H_2SO_4. When reduction is complete add sodium carbonate or dilute hydrochloric acid to neutralize the solution. Wash into drain with large excess of water.

Program References:
Alchem 10: B2, D2; omit both since solid required.
Keys to Chemistry: 6-5, 10-2, 11-1, 11-2; use commercially supplied $0.1M$ or $0.5M$ solutions.
Chemistry: Experiments and Principles, (Davis *et al.*), Ex. 18, 20, 21, 23, 30; use commercially supplied $0.1M$ or $0.5M$ solutions.

POTASSIUM DICHROMATE $K_2Cr_2O_7$

HUMAN CARCINOGEN AS DUST.
CONTACT WITH COMBUSTIBLE MATERIAL MAY CAUSE FIRE.
HARMFUL IF TAKEN INTERNALLY

Physical Properties:
Bright orange–red crystals; mp 398°C.

Chemical Properties:
Soluble in water; oxidizing agent.

Hazardous Reactions:
Boron. Mixtures of boron and potassium dichromate with or without silicon may ignite.
Hydroxylamine. Aqueous hydroxylamine ignites on contact with potassium dichromate moistened with sulfuric acid. The anhydrous base explodes violently on contact with potassium dichromate.

Physiological Properties and Health Hazards:
Dust irritates respiratory tract and eyes. Swallowing causes irritation and internal damage. Prolonged skin exposure can result in ulceration, liver and kidney damage and cancer. Avoid inhaling dust. Avoid contact with eyes and skin.

Spillage Disposal:
Cover with sodium thiosulfate or sodium bisulfite. Scoop slurry into a container of water and neutralize. Wash down drain with excess water.
Site of spillage should be washed thoroughly to remove all oxidant, which is liable to render any organic matter (particularly wood, paper and textiles) with which it comes into contact, dangerously combustible when dry. Clothing wetted with the solution should be washed thoroughly.

Waste Disposal:
Add to a large volume of concentrated solution of sodium thiosulfate, sodium bisulfite or a ferrous salt and acidify with 3*M* H_2SO_4. When reduction is complete add sodium carbonate or dilute hydrochloric acid to neutralize the solution. Wash into drain with large excess of water.

Program References:
Alchem 10: B2, D1; omit both since solid required.
Alchem 20: I3(D); use commercially supplied 0.1*M* solution.
Alchem 30: M3; use commercially supplied 0.13*M* solution.
Chemistry: Experiments and Principles, (Davis *et al.*), Ex. 30, 38; use commercially supplied 0.1*M* solution.

POTASSIUM FLUORIDE KF

POISONOUS

Hazard Rating:
Health 3.

Physical Properties:
White, deliquescent powder or solid; bp 859.9°C.

Chemical Properties:
Freely soluble in boiling water; soluble in water, hydrofluoric acid; insoluble in alcohol. Aqueous solution erodes glass and porcelain.

Physiological Properties and Health Hazards:
Breathing dust or swallowing the powder will cause severe poisoning. Irritates the skin, eyes, mucous membrane and tissue.

Spillage Disposal:
Sweep into a beaker. Dilute with sufficient water. Add sodium carbonate and calcium hydroxide. Mix and neutralize with 6*M* HCl. Drain into the sewer with abundant water.

Waste Disposal:
Slowly add to a large container of water. Add sodium carbonate and calcium hydroxide slowly with stirring. After 24 hours, decant or siphon into another container. Neutralize with 6*M* HCl and drain into the sewer with abundant water.

Storage:
Store away from mineral and organic acids in poison cupboard.

Handling:
Wear safety glasses and gloves.

POTASSIUM HYDRIDE KH

FLAMMABLE IN MOIST AIR. REACTS VIOLENTLY WITH WATER.

Hazardous Reactions:

Air. Ignites on exposure to air.
Fluorine. Ignites on contact at room temperature.

Spillage Disposal:

Wear rubber gloves, fire proof clothing and face shield. Keep available pulverized dolomite or dry graphite for fire fighting.
Spills. Eliminate all sources of ignition. Mix with dry sand to avoid or stop fire. Place in fume hood. Follow waste disposal procedure.

Waste Disposal:

For reaction mixtures: In a fume hood, mix with dry sand to avoid or stop fire. *Cautiously* and slowly add DRY isopropyl or butyl alcohol until reaction ceases. Later add water until last of hydride is destroyed. Scoop the solid into a large container. Neutralize with 6*M* HCl. Let settle. Decant and flush to sewer with excess water. Discard sand.
For packaged lots: Place in separate labelled container for disposal.

Storage:

Protect containers from physical damage. Store in a cool, *dry* place with other reducing agents and isolated from other chemicals.

Handling:

Wear safety glasses and gloves.

POTASSIUM NITRITE KNO_2

CONTACT WITH COMBUSTIBLE MATERIAL MAY CAUSE FIRE. HARMFUL SUBSTANCE IF TAKEN INTERNALLY.

Physical Properties:
White or slightly yellow, deliquescent, crystalline solid; mp 441°C; soluble in water.

Fire Hazard:
Avoid contact with clothing and other absorbent fabrics.

Hazardous Reactions:
Ammonium sulfate. Addition to the fused nitrite causes effervescence and ignition.

Spillage Disposal:
Shovel into bucket of water and run solution to waste diluting greatly with running water. Site of spillage should be washed thoroughly to remove all oxidant. Clothing wetted by a solution of the nitrite should be washed thoroughly.

Waste Disposal:
In the fume hood, add product to a large excess of water. *Cautiously* and slowly add sodium bisulfite. Acidify if reaction does not proceed spontaneously. Wash down the drain with excess water.

Storage:
Store separate from combustible materials and ammonium, cyanide or thiocyanate salts. Do not store on wood.

Handling:
Wear safety glasses and gloves.

beta-PROPIOLACTONE (oxetan-2-one) $C_3H_4O_2$

ANIMAL CARCINOGEN. TOXIC IN CONTACT WITH SKIN. IRRITATING TO SKIN, EYES AND RESPIRATORY SYSTEM.

Physical Properties:

Colorless liquid; bp 162°C with decomposition.

Chemical Properties:

Slowly hydrolyzed in water to hydracrylic acid.

Physiological Properties and Health Hazards:

Severe skin irritant. Skin cancers produced in animals. Swallowing would result in dangerous irritation.

Prevent contact with skin, eyes and clothing. Prevent inhalation of vapor.

An experimental carcinogen by oral, subcutaneous, intratracheal and dermal routes of the skin and connective tissue.

Spillage Disposal:

Wear face shield or goggles, and gloves. Absorb on paper. Package and follow waste disposal.

Site of spillage should be washed thoroughly with water and soap.

Waste Disposal:

Place in a separate, labelled container for disposal by burning.

PROPYLENEIMINE (2-methylaziridine) $-CH_2CH(CH_3)NH-$

OF UNKNOWN CARCINOGENICITY

Physical Properties:
Liquid

Chemical Properties:
Emits toxic fumes of NO when heated to decomposition, can react with oxidizing materials.

Hazardous Reactions:
Acids. Polymerizes explosively in contact with acids or acidic fumes. It must be stored over solid alkali.

Physiological Properties and Health Hazards:
An experimental carcinogen by dermal route.

Spillage Disposal:
Wear butyl rubber gloves, face shield or self-contained breathing apparatus, laboratory coat.
Cover with sodium bisulfate. Spray with water and wash into drain with large excess of water.

Waste Disposal:
Place in a separate, labelled container for disposal by burning.

RESORCINOL $C_6H_4(OH)_2$

IRRITATING DUST

Physical Properties:
White needles. Changes to pink on exposure to light and air, or in contact with iron. mp 110.7°C, bp 281°C.

Fire Hazard:
Flammable. Flash point 127°C; ignition temp 607°C; lower explosion limit 1.4%.

Chemical Properties:
Soluble in water, ethanol, ether, glycerol, benzene; slightly soluble in chloroform.

Physiological Properties and Health Hazards:
Irritates skin, eyes and mucous membranes.

Spillage Disposal:
Sweep up solid with brush and follow waste disposal procedure.

Waste Disposal:
Place in a separate, labelled container for disposal by burning.

Storage:
Store in general chemical stores.

Handling:
Wear safety glasses and gloves.

RHODANINE (2-thiono-4-thiazolidinone) $C_3H_3NOS_2$

MAY EXPLODE ON RAPID HEATING

Physical Properties:
Pale yellow crystals, mp 168.5°C (capillary) 170.5–171°C (hot stage).

Chemical Properties:
May explode on rapid heating.
Freely soluble in boiling water.

Spillage Disposal:
Wear goggles and gloves. Sweep up into container and follow waste disposal procedure.

Waste Disposal:
Place in a separate, labelled container for disposal by burning.

Storage:
Store in general chemical stores away from heat.

Handling:
Wear safety glasses.

SELENIUM AND COMPOUNDS Se

SERIOUS RISK OF POISONING BY INHALATION OR SWALLOWING. IRRITATING TO SKIN, EYES AND RESPIRATORY SYSTEM. DANGER OF CUMULATIVE EFFECTS.

Hazard Rating:
Health 3; Fire 2; Reactivity 0.

Physical Properties:
Selenium is a steel gray or purplish powder, also fabricated into pellets, sticks or plates. Selenium dioxide, selenous acid and the alkali–metal selenites and selenates are colorless powders or crystals; selenium chloride (reddish yellow), selenyl chloride (colorless or yellow) (bp 176°C); and selenic acid (colorless are liquids, whereas selenium tetrachloride is a cream–colored crystalline solid.

Chemical Properties:
Selenium powder is insoluble in water; the dioxide, selenous acid, and the alkali metal selenites are water–soluble. Highly poisonous hydrogen selenide (offensive smell) is generated when an acid solution of a selenium compound is reduced by metals such as tin and zinc. Selenic acid reacts vigorously with water.

Hazardous Reactions:
Metal Chlorates. Selenium incandesces when mixed with any slightly moist chlorate other than alkali metal chlorates.
Metals. Nickel, sodium, potassium, uranium, zinc, and platinum sponge interact with selenium with incandescence when gently heated. The particle size of cadmium and selenium must be below a critical size to prevent explosions when making cadmium selenide; this also applies to zinc.
Oxidants. Selenium may react explosively with BrF_5, ClF_3 or N_2O_2 and it ignites on contact with F_2.
Oxygen and Organic Matter. Heating selenium in oxygen in the presence of traces of organic impurities may result in a vigorous explosion.
Phosphorus. A warm mixture incandesces.

Physiological Properties and Health Hazards:
Hydrogen selenide irritates the nose, eyes and lung tissue and disturbs the digestive and nervous systems. Solutions of selenium compounds may burn the skin and cause severe pain by skin absorption. Selenium dioxide dust irritates the respiratory system, eyes and skin and is particularly harmful by skin absorption. Swallowing will cause severe irritation and poisoning. Prolonged exposure to selenium dust may cause dermatitis, fatigue, digestive upset, and bronchitis.
Avoid breathing dust. Avoid contact with skin and eyes.

Spillage Disposal:
Selenium powder may be mixed with sand and treated as normal refuse, as may the disulfide. Soluble selenites and selenates can be dissolved in water and run to waste, diluting greatly with running water. Sodium carbonate should be applied liberally to spillages of selenium dioxide, selenic and selenous acids and selenyl and selenium chlorides which may then be mopped up cautiously with plenty of water, this being run to waste, diluting greatly with running water.

Waste Disposal:
Place solution in an evaporating dish in the fume hood. When all the liquid has evaporated, place the residue in a labelled sealed container for disposal.

Storage:
Store in cool dry area.

Handling:
Wear safety glasses and gloves. Use fume hood.

SODIUM AND SODIUM AMALGAM

Na, Na(Hg)

CONTACT WITH WATER LIBERATES HIGHLY FLAMMABLE GASES. CAUSES BURNS.

Hazard Rating:

Health 3; Fire 1; Reactivity 2.

Physical Properties:

Sodium: soft, silvery white sticks, pellets, wire or granules; normally coated with a gray oxide or hydroxide skin.
Sodium amalgam: silvery or gray spongy masses.

Fire Hazard:

Ignites spontaneously in air or oxygen, releases hydrogen on contact with water. Use soda ash or dry chemical to extinguish.

Chemical Properties:

Sodium: reacts vigorously with water with formation of sodium hydroxide and hydrogen gas which may ignite.
Sodium amalgam: reacts with water forming sodium hydroxide and hydrogen gas.

Preparation of Clean Sodium. The cleaning of sodium by cutting off the oxidized surfaces with a knife under xylene is tedious and wasteful. The following technique facilitates the operation, saves metal, and minimizes scrap disposal. Considerably more sodium than will be needed is placed in a wide-mouthed Erlenmeyer flask or tall beaker and covered with dry xylene. The flask is heated until the sodium melts but stays in the cage of surface oxide. The heating source is then removed and the flask swirled gently to cause the sodium to flow out of the shells and form several globules. The flask is then cooled without much agitation in order that the sodium globules do not unite. As a precaution, dry nitrogen can be passed through the solution during cooling. When the metal has solidified, the clear globules are removed with a pointed iron rod or other device, dried rapidly with filter paper or a *dry* towel, and added to the weighed container used to measure the amount of sodium needed. The oxide shells contain very little sodium: the solvent is decanted, and treatment of the residue with *t*-butanol destroys traces of active metal.

Hazardous Reactions:

Acids. Anhydrous HCl, HF or H_2SO_4 react slowly with sodium while aqueous solutions react explosively.
Air. Dispersions of sodium in volatile solvents become pyrophoric if the solvent evaporates round the neck of a flask; serum cap closures are safer.
Chloroform, Methanol. Addition of Na to an inadequately cooled chloroform-methanol solution caused a violent explosion.
Diethyl ether. While sodium wire was being pressed into ether, the jet blocked. Increasing the pressure to free it caused ignition of the ejected sodium and explosion of the flask of ether. Pressing the sodium into xylene or toluene and subsequent transfer to the ether is recommended.
N,N-Dimethylformamide. Vigorous reaction occurs on heating Na in this solvent.
Ethanol. Air must be excluded when reacting finely divided Na with ethanol to avoid hydrogen-air mixture explosions.
Halocarbons. Sodium in carbon tetrachloride, chloroform, dichloromethane and chloromethane and tetrachloroethane forms shock and impact sensitive mixtures. Any aliphatic halocarbon (except fully fluorinated alkanes) may be expected to behave in this way.
Halogens or Interhalogens. Ignites in F_2 gas and in moist Cl_2; mixtures with I_2 liquid, Br_2, IBr or ICl are shock-sensitive.
Hydrazine. Mixture with anhydrous hydrazine forms sodium hydrazide which explodes on contact with air; with hydrazine hydrate there is strongly exothermic reaction to give H_2 and NH_3.
Mercury. Reaction is violently exothermic.
Metal Halides. Dispersions of Na reduce many metal halides to finely powdered metals, many of which are pyrophoric; mixtures of Na with metal halides are sensitive to mechanical shock.

Metal Oxides. Finely dispersed Na reduces metal oxides on heating at temperatures between 100°C and 300°C producing pyrophoric metal powders.
Non-Metal Halides. Vigorous or explosive reactions occur with PBr_3 on addition of drops of water, PCl_3, PCl_5, diselenium dichloride,, SCl_2, BBr_3, SBr_2, seleninyl bromide, phosphoryl chloride, sulfinyl fluoride, silicon tetrachloride and silicon tetrafluoride.
Non-Metal Oxides. Mixtures with solid CO_2 are impact-sensitive and explode violently; CO_2 is unsuitable as an extinguishant for the burning metal alone, as the intensity of combustion is increased by replacing air with CO_2; finely divided silica will often react with burning Na so it is not suitable as an extinguishant.
Non-Metals. Explosions occur when carbon powder is in contact with Na in the presence of air; violent reactions occur with sulfur, selenium, and molten tellurium.
Oxygenated Compounds. Mixtures of Na with inorganic oxygenated compounds or oxygen-rich organic cmpounds are shock-sensitive explosives.
Sulfides. Mixtures of Na with CS_2 are shock sensitive explosives.
Water. Vigorous reaction with small pieces of Na, explosion with large lumps, violent explosion with ice.

Physiological Properties and Health Hazards:
Sodium reacts with skin moisture to yield sodium hydroxide and cause heat and caustic burns to skin and eyes.
Avoid contact with skin and eyes.

Spillage Disposal:
(a) Sodium metal: Instruct others to keep at a safe distance. Wear face shield or goggles, and gloves. Cover with dry sodium carbonate, shovel into dry bucket, transport to fume hood. Behind a shield add, a little at a time, to a large excess of dry isopropanol. Leave to stand for 24 hours and run to waste, diluting greatly with running water.
(b)Sodium amalgam: cover with large volume of water in suitable vessel and allow to stand until there is no further reaction; the mercury may then be separated and recovered, and the sodium hydroxide solution run to waste, diluting greatly with running water.

Waste Disposal:
In a discussion of safe methods for laboratory use of sodium, disposal of small quantities (up to 5 - 10 g) by immersion in isopropanol which may contain up to 2% of water to increse the rate of reaction, is recommended. Quantities up to 50 g should be burned in a heavy metal dish, using a gas flame. Handling techniques and safety precautions for large-scale operations have also been detailed for this reactive metal.

Storage:
Store under mineral oil with reducing agents.

Handling:
Wear safety glasses and gloves.

SODIUM AZIDE NaN_3

TOXIC IF TAKEN INTERNALLY. CONTACT WITH ACIDS LIBERATES A TOXIC GAS. IRRITATING TO SKIN AND EYES. EXPLOSIVE

Hazard Rating:
Health 3; Fire 2; Reactivity 2.

Physical Properties:
Crystals, dec. on heating; soluble in water.

Chemical Properties:
Insensitive to impact, it decomposes, sometimes explosively, above the mp, particularly if heated rapidly.

Hazardous Reactions:
Bromine. Liable to explode in presence of Br_2 vapor.
Carbon disulfide. Aqueous solution of NaN_3 forms explosive mixture with CS_2.
Heavy Metals. Contact of aqueous solutions with heavy metals (brass, Cu, Pb) may lead to the formation of explosive heavy metal azides, (e.g. in plumbing lines).
Hydrochloric acid. A serious explosion occurred when prednisone was treated with sodium azide and concentrated HCl.
Sulfuric acid. Forms explosive solution in 50% H_2SO_4 unless acid is quite cold.
Water. Violent reaction when water is added to strongly heated azide.

Physiological Properties and Health Hazards:
Dust irritates the eyes. Solution irritates the skin and the eyes. Swallowing assumed to cause irritation and poisoning.
Prevent contact with skin and eyes. Avoid breathing dust.

Spillage Disposal:
Wear face shield or goggles and gloves. Dampen and brush onto paper with great care. Place in plastic bag for disposal by burning.

Waste Disposal:
In the fume hood, behind a shield, cautiously and slowly add to a greater-than-stoichiometric amount of ceric ammonium nitrate solution with agitation sufficient to provide suspension of all solids. Cool the reaction. Then wash down the drain with plenty of water.

SODIUM CHLORATE $NaClO_3$

EXPLOSIVE WHEN MIXED WITH COMBUSTIBLE MATERIAL. HARMFUL IF TAKEN INTERNALLY.

Hazard Rating:
Health 1; Fire 0; Reactivity 2.

Physical Properties:
Colorless crystals, or white granules; soluble in water; mp 248°C.

Fire Hazard:
Mixtures of sodium chlorate and combustible materials are readily ignited; mixtures with finely divided combustible materials can react explosively. Extinguish fire with water spray.

Hazardous Reactions:
Ammonium Salts or Metals or Non-Metals or Sulfides. Mixtures with ammonium salts, powdered metals, phosphorus, silicon, sulfur or sulfides are readily ignited and potentially explosive.
Nitrobenzene. Mixture is powerfully explosive.
Organic Matter. Mixtures with fibrous or absorbent organic materials (charcoal, flour, shellac, sawdust, sugar) are hazardous and can be caused to explode by static friction or shock.
Paper, Static Electricity. Paper impregnated with the chlorate can be ignited by static sparks.
Phosphorus. Mixture explodes violently.
Sulfuric acid. Addition of concentrated H_2SO_4 causes explosion of ClO_2 generated.
Wood. Wood in contact with the chlorate over a period of time may ignite or explode.

Physiological Properties and Health Hazards:
Dust irritates eyes and skin. Swallowing solutions or solid results in nausea, abdominal pain and vomiting and possible kidney damage.
Avoid contact with combustible materials and acids. Avoid contact with skin, eyes and clothing.

Spillage Disposal:
Wear face shield or goggles and gloves. Cover with weak reducing agents such as sodium thiosulfate or sodium bisulfite. Bisulfites need additional promoter of some 3*M* H_2SO_4 to accelerate reaction. Transfer the slurry (or sludge) into a large container of water and neutralize with sodium carbonate. Drain into a sewer with abundant water.

Waste Disposal:
In the fume hood, behind a shield, *cautiously* and slowly add to a large volume of concentrated solution of sodium thiosulfate or sodium bisulfite (may require 3*M* H_2SO_4 to accelerate reaction). Neutralize and drain into a sewer with abundant water.

Storage:
Store separate from mineral acids, organic compounds, and ammonium salts. Do not store on wood. Immediately remove and dispose of any spilled chlorate.

Handling:
Wear gloves, face shield and work behind safety shield.

Program References:
Keys to Chemistry: 11-1, 11-2; use commercially supplied 0.1*M* solutions. To avoid forming chlorine gas in detecting ClO_3^- use the following test. To a solution of ClO_3^- add 3-4 drops of 0.1*M* $AgNO_3$ solution and 1-2 drops of 0.2*M* $NaNO_2$ solution. The appearance of a white precipitate (AgCl) confirms ClO_3^-.

SODIUM CHROMATE Na_2CrO_4

HUMAN CARCINOGEN AS DUST
CONTACT WITH COMBUSTIBLE MATERIAL MAY CAUSE FIRE. HARMFUL IF TAKEN INTERNALLY

Physical Properties:

Yellow deliquescent crystals; crystallizes as *tetra*– or *deca*hydrate. Decahydrate loses water; mp 792°C (decahydrate mp 20°C).

Physiological Properties and Health Hazards:

Dust irritates respiratory tract and eyes. Swallowing causes irritation and internal damage. Prolonged exposure causes ulceration, damage to liver and kidneys and even cancer. Avoid inhaling dust. Avoid contact with eyes and skin.

Spillage Disposal:

Cover with sodium thiosulfate or sodium bisulfite. Mix well and spray with water, scoop slurry into a container of water and neutralize. Wash down drain with excess water.
Site of spillage should be washed thoroughly to remove all oxidant, which is liable to render any organic matter (particularly wood, paper and textiles) with which it comes into contact, dangerously combustible when dry. Clothing wetted with the solution should be washed thoroughly.

Waste Disposal:

Add to a large volume of concentrated solution of sodium thiosulfate, sodium bisulfite or a ferrous salt and acidify with $3M$ H_2SO_4. When reduction is complete add sodium carbonate or dilute hydrochloric acid to neutralize the solution. Wash into drain with large excess of water.

Program References:

Alchem 10: C3; use commercially supplied $0.1M$ solution.
Keys to Chemistry: 10–1; omit heating sodium chromate in Part II.
Chemistry: Experiments and Principles, (Davis *et al.*), Ex. 18; use commercially supplied $0.1M$ solution.

SODIUM DICHROMATE $Na_2Cr_2O_7$

HUMAN CARCINOGEN AS DUST.
CONTACT WITH COMBUSTIBLE MATERIAL MAY CAUSE FIRE.
HARMFUL IF TAKEN INTERNALLY

Physical Properties:

Dihydrate: reddish to bright orange, somewhat deliquescent crystals; lose water on prolonged heating at about 100°C.
Anhydrous; mp 356.7°C.

Chemical Properties:

Very soluble in water; oxidizing agent.

Hazardous Reactions:

Boron. Mixtures in the presence or absence of silicon may ignite.
Ethanol. Oxidation of ethanol with acid dichromate may result in minor explosion.
Hydroxylamine. Violent reaction between sodium dichromate dihydrate and aqueous hydroxylamine may accelerate to explosion. Anhydrous hydroxylamine explodes violently on contact with sodium dichromate.
Sulfuric acid. Vessels containing tarry residues or traces of oxidizable substances should not be placed in dichromate and sulfuric acid cleaning solutions; violent reactions may result.
Trinitrotoluene. In the oxidation of trinitrotoluene to trinitrobenzene, the reaction mixture must be stirred vigorously to prevent the addition of a portion of sodium dichromate causing local ignition.

Physiological Properties and Health Hazards:

Dust irritates respiratory tract and eyes. Swallowing causes irritation and internal damage. Prolonged exposure to the dust causes skin ulceration, damage to liver and kidneys, and even cancer.
Avoid inhaling dust. Avoid contact with skin and eyes.

Spillage Disposal:

Cover with sodium thiosulfate or sodium bisulfite. Scoop slurry into a container of water and neutralize. Wash down drain with excess water.
Site of spillage should be washed thoroughly to remove all oxidant, which is liable to render any organic matter (particularly wood, paper and textiles) with which it comes into contact, dangerously combustible when dry. Clothing wetted with the solution should be washed thoroughly.

Waste Disposal:

Add to a large volume of concentrated solution of sodium thiosulfate, sodium bisulfite or a ferrous salt and acidify with 3*M* H_2SO_4. When reduction is complete add sodium carbonate or dilute hydrochloric acid to neutralize the solution. Wash into drain with large excess of water.

Program References:

Chemistry: Experiments and Principles, (Davis *et al*.), Ex. 36; use commercially supplied 0.1*M* solution.

SODIUM FLUORIDE NaF

POISONOUS.

Hazard Rating:
Health 2; Fire 0; Reactivity 0.

Physical Properties:
Clear lustrous crystals of cubic tetragonal form, or white powder; mp 993°C.

Chemical Properties:
Soluble in water; very slightly soluble in alcohol. Aqueous solutions have alkali reaction and etch glass.

Physiological Properties and Health Hazards:
Dust irritates respiratory tract, eyes and skin. Swallowing results in nausea, stomach pains, vomiting, and diarrhea. Prolonged exposure causes shortness of breath, cough and cyanosis.

Spillage Disposal:
Sweep into a beaker. Dilute with sufficient water. Add sodium carbonate. Mix and neutralize with 6*M* HCl. Drain into the sewer with abundant water.

Waste Disposal:
Remove slowly into a large container of water. Add sodium carbonate slowly with stirring. After 24 hours, decant or siphon into another container. Neutralize with 6*M* HCl, and drain into the sewer with abundant water.

Storage:
Store away from mineral and organic acids in poison cupboard.

Handling:
Wear safety glasses and gloves.

SODIUM HYDRIDE NaH

FLAMMABLE IN MOIST AIR. REACTS VIOLENTLY WITH WATER.

Hazard Rating:
Health 3; Fire 3; Reactivity 2.

Physical Properties:
Silvery needles; the commercial product is a gray–white powder. Dec 425°C.

Fire Hazard:
Flammable solid, may ignite in moist air. Do not use water, carbon dioxide, dry chemical or halogenated extinguishers. Extinguish by smothering.

Chemical Properties:
Reacts explosively with water, violently with lower alcohols; ignites spontaneouosly on standing in moist air.

Hazardous Reactions:
Acetylene. Reacts vigorously in the presence of moisture even at −60°C.
Air. The finely divided dry powder ignites in dry air.
Dimethyl sulfoxide. Mixture explodes if heated above 70°C.
Halogens. Incandesces in Cl_2 or F_2 at room temperature and in I_2 at 100°C.
Sulfur dioxide. Reacts explosively with SO_2.
Water. Addition to a small amount of water causes explosion.

Spillage Disposal:
Wear rubber gloves, fire proof clothing and face shield. Keep available pulverized dolomite or dry graphite for fire fighting.
Spills. Eliminate all sources of ignition. Mix with dry sand to avoid or stop fire. Place in fume hood. Follow waste disposal procedure.

Waste Disposal:
For reaction mixtures: In a fume hood, mix with dry sand to avoid or stop fire. *Cautiously* and slowly add dry isopropyl or butyl alcohol until reaction ceases. Later add water until last of hydride is destroyed. Scoop the solid into a large container. Neutralize with 6*M* HCl. Let settle. Decant and flush to sewer with excess of water. Discard sand.
For packaged lots: Place in a separate labelled container for disposal.

Storage:
Protect containers from physical damage. Store in a cool, *dry* place with other reducing agents and isolated from other chemicals.

Handling:
Wear safety glasses and gloves.

SODIUM NITRITE $NaNO_2$

CONTACT WITH COMBUSTIBLE MATERIAL MAY CAUSE FIRE

Physical Properties:
White or slightly yellow granules, rods or powder; hygroscopic; soluble in water; mp 271°C.

Fire Hazard:
Mixtures of sodium nitrite and combustible materials are readily ignited; mixtures with finely divided combustible materials can react explosively. Extinguish fire with water spray.

Chemical Properties:
Poisonous nitrous fumes produced by the action of acids. Avoid contact with combustible materials or acids.

Hazardous Reactions:
Amidosulfates. Warming with metal amidosulfates (sulfamates) may become explosively violent.
Ammonium Salts. Violent explosion occurs on heating a mixture.
Metal Cyanides. Mixtures explode on heating.
Phenol. Mixture explodes violently on heating.
Phthalic acid or Phthalic anhydride. Mixtures explode violently on heating.
Sodium thiocyanate. Mixture explodes on heating.
Sodium thiosulfate. Mixture of solutions does not react violently; solid mixture explodes on heating.
Urea. Conditions for fusion with urea must be exactly as described to avoid risk of explosion.
Wood. Wood impregnated with solutions of the nitrite over a long period will burn fiercely if accidentally ignited.

Waste Disposal:
Add solid to an equal volume of sodium carbonate. Transfer to a large container and dilute with water to obtain a slurry. *Cautiously* add calcium hypochlorite with stirring. After one hour dilute with water. Adjust pH to 7 and drain to sewer with abundant water.

Storage:
Store separate from combustible materials and ammonium, cyanide or thiocyanate salts. Do not store on wood.

Handling:
Wear safety glasses and gloves.

Program References:
Keys to Chemistry: 11–2.

STANNIC CHLORIDE (tin(IV) chloride, tin tetrachloride) $SnCl_4$

CAUSES BURNS. IRRITATING TO SKIN, EYES AND RESPIRATORY SYSTEM

Hazard Rating:
Health 3; Fire 0; Reactivity 1.

Physical Properties:
Colorless fuming liquid; bp 114°C.

Chemical Properties:
Reacts with water forming hydrochloric acid.

Hazardous Reactions:
Potassium. Mixture explodes violently on impact.
Sodium. Mixture explodes violently on impact.
Turpentine. Reaction is strongly exothermic and may ignite.

Physiological Properties and Health Hazards:
The vapor irritates the respiratory system. The vapor irritates the eyes. The liquid irritates the eyes and skin and may cause burns. Will result in internal irritation and damage if taken by mouth.
Avoid contact with skin and eyes. Do not put water into container.

Spillage Disposal:
Instruct others to keep at a safe distance. Wear breathing apparatus and gloves. Spread dry sodium carbonate liberally over the spillage and mop up *cautiously* with water; run to waste, diluting greatly with running water.

Waste Disposal:
Place solution in an evaporating dish in the fume hood. When all the liquid has evaporated, place the residue in a labelled sealed container for disposal.

Storage:
Store with mineral acids in general acids store.

Handling:
Wear safety glasses and gloves. Handle in the fume hood.

STRONTIUM Sr

MAY IGNITE IN AIR

Physical Properties:
Silvery-white metal; rapidly becomes yellow on exposure to air.

Hazardous Reactions:
Air. The finely divided metal may ignite in air.
Halogens. Incandesces in chlorine at 300°C and ignites in bromine at 400°C.
Water. Vigorous interaction.

Spillage Disposal:
Cautiously dissolve in a large amount of water. Add sodium carbonate and mix. Neutralize. Flush down drain with plenty of water.

Waste Disposal:
Place solution in an evaporating dish in the fume hood. When all the liquid has evaporated, place the residue in a labelled sealed container for disposal.

Storage:
Store under liquid paraffin with reducing agents.

Handling:
Wear safety glasses and gloves.

SULFAMIC ACID (sulfamidic acid; amidosulfuric acid) HSO_3NH_2

IRRITATING TO SKIN AND EYES.

Hazard Rating:
Health 2; Fire 0; Reactivity 3.

Physical Properties:
White crystals melting at about 205°C with decomposition.

Chemical Properties:
One part dissolves in about six parts water at 0°C, in about two parts at 80°C.

Hazardous Reactions:
Nitrates or Nitrites. Heating with mixtures of sodium or potassium nitrates or nitrites leads to reactions which may be explosive.

Physiological Properties and Health Hazards:
Dust or solution irritates eyes. Prolonged exposure of skin to the acid may cause irritation.
Avoid contact with skin and eyes.

Spillage Disposal:
Wear face shield or goggles, and gloves. Clean up with dust pan and brush. May be disposed of after mixing with sand as normal refuse or flushed away to waste with water.

Waste Disposal:
Sift slowly into a large container of cold water, with agitation. When all has dissolved, neutralize and pour into drain with large excess of water.

Storage:
Store in general chemical stores away from ammonium salts.

Handling:
Wear safety glasses.

SULFURIC ACID H_2SO_4

CAUSES SEVERE BURNS. DO NOT ADD WATER TO CONCENTRATED ACID.

Hazard Rating:
Health 3; Fire 0; Reactivity 2.

Physical Properties:
Concentrated sulfuric acid is a colorless, oily liquid; bp 290°C.

Fire Hazard:
May ignite finely divided combustible materials on contact.

Chemical Properties:
Reacts vigorously with water.

Hazardous Reactions:
Acetaldehyde. Polymerized violently by concentrated acid.
Acetone and Nitric acid. Acetone is oxidized violently by a nitric acid and sulfuric acid mixture.
Acetonitrile. Strongly exothermic reaction on warming.
Acrylonitrile. Vigorous reaction on contact with even small quantities of strong acid.
Alkyl Nitrates. Violent reaction with sulfuric acid.
Benzyl alcohol. Decomposes explosively at about 180°C in the presence of 58% H_2SO_4.
Cyclopentadiene. Violent or explosive reaction with concentrated acid.
Metal Acetylides or Carbides. Monocesium and monorubidium acetylides ignite on contact with concentrated H_2SO_4. Hazardous reactions occur with other carbides.
Metal Chlorates. May explode violently with concentrated H_2SO_4.
Metal Perchlorates. Explosive perchloric acid is formed in contact with concentrated H_2SO_4.
Nitric acid and Organic Matter. A violent explosion may occur when organic residues are dissolved in the mixed concentrated acids.
Nitric acid and Toluene. Nitration of toluene with mixed concentrated acids must be carefully controlled or an explosion can result.
Nitroaryl Bases and Derivatives. *o*-Nitroaniline rects almost explosively and *p*-nitroaniline, *p*-nitroacetanilide, aminonitrodiphenyls, aminonitronaphthalenes and some nitro-N-heterocycles react vigorously when heated with H_2SO_4 above 200°C.
Nitromethane. Mixture with H_2SO_4 is susceptible to detonation.
p-Nitrotoluene. Decomposes violently when heated with concentrated H_2SO_4 to 160°C.
Permanganates. Explosion may occur with concentrated acid.
Phosphorus trioxide. Ignites on addition of sulfuric acid.
Potassium. Explosive interaction.
Sodium. Slow reaction with anhydrous acid; explosive reaction with aqueous acid.
Sodium borohydride. Reaction with concentrated H_2SO_4 to yield diborane may be dangerously violent.
Water. Dilution of the acid with water is vigorously exothermic; the acid must always be added to water to avoid local boiling.

Physiological Properties and Health Hazards:
Concentrated acid causes severe burns to skin and eyes. Dilute acid irritates the eyes and skin. Swallowing concentrated acid would cause severe internal damage.
Avoid contact with skin and eyes.

Spillage Disposal:
Wear face shield or goggles, and gloves. Spread dry sodium carbonate liberally over the spillage and mop up cautiously with plenty of water; run to waste, diluting greatly with running water.

Waste Disposal:
Wear face shield or goggles and gloves. *Cautiously* and slowly add to a large amount of solution of sodium carbonate and calcium hydroxide with stirring. Run to waste greatly diluting with water.

Storage:

Store with mineral acids in a cool, well-ventilated cupboard separate from carbides, chlorates, nitrates, permanganates, powdered metals and organic compounds.

Handling:

Wear safety glasses and gloves. Dilute by adding SLOWLY to water in a beaker with stirring.

Handle concentrated acid with care. It reacts VIOLENTLY with water and organic materials with evolution of heat.

Program References:

Biology BSCS Green version, 9.1.
Biology: Investigations in Biology (Benson *et al.*), Investigation 1, 9.
Alchem 10: C3, D2.
Alchem 20: H3, I3(D), I2, J3(D).
Alchem 30: M2, M3, N1(D), N4(D).
Keys to Chemistry: 4-1, 7-4, 8-2, 11-1, 11-2.
Chemistry: Experiments and Principles, (Davis *et al.*), Ex. 23, 29, 30, 31, 36, 37, 38, 39, 40.

TANNIC ACID

$C_{76}H_{52}O_{46}$

ANIMAL CARCINOGEN

Physical Properties:
Yellowish-white to light brown, amorphous, bulky powder or flakes, or spongy masses; faint characteristic odor; astringent taste; gradually darkens on exposure to air and light; dec at 210-215°C.

Chemical Properties:
One gram dissolves in 0.35 mL water.

Physiological Properties and Health Hazards:
An experimental carcinogen of the liver by subcutaneous route.

Spillage Disposal:
Sweep spills onto paper. Follow waste disposal. Wash site of spillage with soap and water.

Waste Disposal:
Place in a separate labelled container for disposal by burning.

THALLIUM AND SALTS Tl

POISONOUS DUST. SERIOUS RISK OF POISONING BY INHALATION OR SWALLOWING. DANGER OF CUMULATIVE EFFECTS

Hazard Rating:
Thallium: Health 3.

Physical Properties:
Thallium – soft bluish-white metal; mp 303.5°C. The carbonate, and sulfate are white, crystalline solids, soluble in water; the oxide is black and forms hydroxide in water.

Physiological Properties and Health Hazards:
The dusts irritate the nose and eyes and may cause nausea and abdominal pain by absorption. The metal on contact with moist skin produces a white film of the hydroxide. Skin absorption of the soluble salts and ingestion may cause nausea, vomiting, abdominal pains, weakness of the legs, and mental confusion.
Chronic Effects. Exposure over a long period to small amounts of the dust or solutions may result in loss of appetite, falling out of hair, pain or weakness of limbs, insomnia and mental disturbance.
Avoid breathing dust. Avoid contact with skin and eyes.

Waste Disposal:
Place solution in an evaporating dish in the fume hood. When all the liquid has evaporated, place the residue in a labelled sealed container for disposal.

Storage:
Store in poison cupboard.

Handling:
Wear safety glasses and gloves. Use fume hood.

o-TOLIDINE AND o-TOLIDINE DIHYDROCHLORIDE $(CH_3C_6H_4(NH_2)-)_2$
(2,2'-dimethylbenzidine)

SUSPECTED ANIMAL CARCINOGEN. POISONOUS DUST. TOXIC IN CONTACT WITH SKIN. DANGER OF CUMULATIVE EFFECTS.

Physical Properties:

White to reddish crystals or powder; mp 129–131°C (base).

Chemical Properties:

Slightly soluble in water.

Physiological Properties and Health Hazards:

The dihydrochloride and its solutions irritate the skin and eyes. Prolonged exposure can cause bladder cancer.

Avoid inhalation of dust. Avoid contact with skin and eyes.

An experimental carcinogen by oral, subcutaneous and implantation routes.

Spillage Disposal:

Wear breathing apparatus and gloves. Mix spillage with moist sand and shovel mixture into glass, enamel or polythene vessels for dispersion in an excess of dilute hydrochloric acid (1 volume of concentrated acid diluted with 2 volumes of water). Allow to stand, with occasional stirring, for 24 hours and then run extract to waste, diluting greatly with running water and washing the sand. The residual sand can be treated as normal refuse. The site of the spillage should be washed with water and soap.

Waste Disposal:

Place in a separate, labelled container for disposal by burning.

TOLUENE $C_6H_5CH_3$

HIGHLY FLAMMABLE. HARMFUL VAPOR.

Hazard Rating:
Health 2; Fire 3; Reactivity 0.

Physical Properties:
Colorless liquid with characteristic odor; bp 111°C.

Fire Hazard:
Flash point 4.4°C; explosive limits 1.4–6.7%; ignition temperature 536°C. Extinguish fire with foam, dry powder, carbon dioxide, or vaporizing liquid.

Chemical Properties:
Immiscible with water.
Nitric acid and Sulfuric acid. Inadequate control in nitration of toluene with mixed acids may lead to a runaway or explosive reaction.

Physiological Properties and Health Hazards:
Vapor irritates eyes and mucous membranes and may cause dizziness, headache, nausea and mental confusion. The liquid irritates the eyes and mucous membranes and may cause dermatitis. Swallowing or absorption through the skin would cause poisoning.
Avoid breathing vapor. Avoid contact with skin and eyes.

Spillage Disposal:
Shut off all possible sources of ignition. Wear face–shield or goggles, and gloves. Absorb on paper and transport to fume hood for evaporation. Ventilate site of spillage well to evaporate remaining liquid and dispel vapor.

Waste Disposal:
Place in non–halogenated solvent disposal container for disposal by burning.

Storage:
Store in general flammable solvent storage cabinet away from sources of ignition.

Handling:
Wear safety glasses.

VINYL BROMIDE (bromoethylene) $CH_2=CHBr$

ANIMAL CARCINOGEN. EXTREMELY FLAMMABLE. VERY TOXIC BY INHALATION.

Physical Properties:
Colorless liquid or gas; bp 16°C; insoluble in water.

Fire Hazard:
Flash point below −8°C. Extinguish fire with water spray, foam, dry powder, carbon dioxide or vaporizing liquid.

Physiological Properties and Health Hazards:
Inhalation of vapor in high concentrations may produce dizziness and narcosis. The liquid irritates the eyes and may irritate the skin by its defatting action; it is assumed to be harmful if taken by mouth. In view of the recent observation that vinyl chloride (see below) can cause a cancer of the liver, it must be assumed that vinyl bromide is likely to behave in a similar manner.
Prevent inhalation of vapor. Prevent contact with skin and eyes.

Spillage Disposal:
Evacuate area and allow to evaporate.

Waste Disposal:
Send unopened, labelled container for disposal by burning.

VINYL CHLORIDE (chloroethylene) $CH_2=CHCl$

HUMAN CARCINOGEN. EXTREMELY FLAMMABLE. VERY TOXIC BY INHALATION. DANGER OF VERY SERIOUS IRREVERSIBLE EFFECTS

Physical Properties:

Colorless gas with pleasant sweet odor; bp −14°C; slightly soluble in water.

Fire Hazard:

Flash point −78°C; explosive limits 4.33%; ignition temp 472°C. Since the gas is supplied in a cylinder, turning off the valve will reduce any fire involving it; if possible, cylinders should be removed quickly from an area in which a fire has developed.

Hazardous Reactions:

Discharge of a spray of vapor and liquid under pressure from a cylinder into a fume hood caused ignition of the vapor due to static electricity. Discharge of the gas only did not cause static buildup. Traces of peroxide cause explosive polymerization.

Physiological Properties and Health Hazards:

Inhalation of vapor in high concentrations produces dizziness and narcosis. The liquid may irritate and burn the skin, the latter due to its freezing action. As a result of observations made in the US (1974), exposure to working atmospheres of vinyl chloride monomer (VCM) has been shown to cause a rare liver cancer, angiosarcoma. This may not manifest itself until over 20 years after initial exposure. The UK Health and Safety Executive has set an interim hygiene standard (Vinyl Chloride Code of Practice for Health Precautions, February 1975) stating that the average concentration of the monomer over a whole working shift must not exceed 25 ppm, and providing that wherever practicable exposure should be brought as near as possible to zero concentration.
Prevent inhalation of gas. Prevent contact with liquid.

Spillage Disposal:

Surplus gas or leaking cylinder can be burnt off through a suitable burner in a fume cupboard.

Waste Disposal:

Dissolve the compound in a combustible solvent and place in a separate, labelled container for disposal by burning.

XYLENES (xylols) $C_6H_4(CH_3)_2$

HARMFUL VAPOR. HARMFUL BY SKIN ABSORPTION. FLAMMABLE.

Hazard Rating:
Health 2; Fire 3; Reactivity 0.

Physical Properties:
Colorless liquids; bps 144°C (*o*–), 139°C (*m*–) and 138°C (*p*–).

Fire Hazard:
Flash points 17°C (*o*–) and 25°C (*m*– and *p*–); explosive limits approximately 1–7%; ignition temperatures 464°C (*o*–), 528°C (*m*–) and 529°C (*p*–). Extinguish fire with foam, dry powder, carbon dioxide, or vaporizing liquid.

Chemical Properties:
Immiscible with water.

Hazardous Reactions:
Air, Acetic acid. The oxidation of *p*–xylene in acetic acid to form terephthalic acid can result in an explosion.
Nitric acid. May detonate immediately on contact with concentrated nitric acid.

Physiological Properties and Health Hazards:
Vapor irritates eyes and mucous membranes and may cause dizziness, headache, nausea and mental confusion. Liquid irritates eyes and mucous membranes. Swallowing or absorption through skin would result in poisoning. Prolonged exposure to skin contact may result in dermatitis.
Avoid breathing vapor. Avoid contact with skin and eyes.

Spillage Disposal:
Shut off all possible sources of ignition. Wear face shield or goggles, and gloves. Absorb on sand, shovel into bucket(s) and transport to fume hood for atmospheric evaporation. Ventilate site of spillage well to evaporate remaining liquid and dispel vapor.

Waste Disposal:
Place waste in non–halogenated solvent disposal container for disposal by burning.

Storage:
Store in general flammable solvent storage cabinet away from sources of ignition.

Handling:
Wear safety glasses.

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